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Illinois State Laboratory

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CHAMPAIGN, ILLINOIS.

VOLUME II.

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ERRATA.*

Page 5, line 3 of table, second column, for 39 read 38 ; line 6, second column for 121 read 120.

Page 9, line 17, for *conjunction* read *conjugation.*

Page 21, line 13, for *Ricciacia* read *Ricciaceæ.*

Page 67, line 17 from bottom, for *fraligifolia* read *fragilifolia.*

Page 123, line 4 from bottom, and page 126, line 1, for *Tricholeæ* read *Trichocoleæ.*

Page 126, line 2, for *Tricholea* read *Trichocolea.*

Page 177, line 16, for *Lecythia* read *Lecythea.*

Page 333, line 1, after Tachidius add Lilljeb.

Page 338, under Daphnella brachyura, line 16, insert *Hab.*—Massachusetts (*Birge*), Minnesota (*Herrick*).

Page 340, line 5, for *Scapaoleberis read Scapholeberis.*

Page 389, line 7 from bottom, for *carpogonium* read *sporocarp* ; lines 9, 12, 15, for *oögonium* read *carpogonium.*

Page 391, line 1, for *Cèssatii* read *Cesatii.*

Page 400, line 4, for *Myceliumin conspicuous* read *Mycelium inconspicuous* ; line 14, for *coleosporium* read *Coleosporium.*

Page 401, line 9, for *connatus* read *connata;* line 12, for *Taraxicum* read *Taraxacum.*

Page 408, line 15, for *macrocarpa* read *macrospora;* line 18, for *Hypohyllous* read *Hypophyllous.*

Pages 470 and 471, head of column 11, for *cyprinella* read *cyprinellus.*

Page 503, lines 8, 14, and 17, for *cyprinella* read *cyprinellus.*

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* For additional errata see page 247.

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ERRATA.

Page 5. Third line of table, second column, for 39, read 38; sixth line, second column, for 121, read 120.

Page 9. Seventeenth line, for conjunction, read *conjugation*.

Page 21. Thirteenth line, for Ricciacæ, read *Ricciaceæ*.

Page 67. Seventeenth line from bottom, for F. fraligifolia, read *F. fragilifolia*.

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When we add to the above the inherent complexity of the group, we begin to see some of the difficulties in the way of study. It is to relieve in part these difficulties, and to stimulate a more complete collection of *Hepaticæ*, particularly in unexplored portions of our country, that the present compilation has been made. That it is at best an imperfect representation of our hepatic flora is painfully apparent to its writer, but it is hoped that it may serve as a stimulus to more work in this

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ARTICLE I.—*Descriptive Catalogue of the North American Hepaticæ, North of Mexico.* By LUCIEN M. UNDERWOOD, PH.D.

PREFATORY NOTE

The study of the *Hepaticæ* is attended with much difficulty for several reasons, among which may be named the following:

1. These plants are very largely neglected by collectors.

2. The literature on the subject is rare and inaccessible. Sullivant's work on the *Hepaticæ*, which seems to have been published in a limited edition, is now a rarity, and can hardly be obtained at any price.

3. Most of our public and college libraries contain little or no literature on this subject.

4. Many of the species described as new by American writers are not represented in any American collection.

When we add to the above the inherent complexity of the group, we begin to see some of the difficulties in the way of study. It is to relieve in part these difficulties, and to stimulate a more complete collection of *Hepaticæ*, particularly in unexplored portions of our country, that the present compilation has been made. That it is at best an imperfect representation of our hepatic flora is painfully apparent to its writer, but it is hoped that it may serve as a stimulus to more work in this

direction, and lay in store material for a more critical examination of this group in the future.

It was the intention of Mr. Austin, of New Jersey, to publish a monograph of this group, but by his death his critical knowledge of the *Hepaticæ* is lost to the world. His private collection, even, has crossed the ocean and is practically lost to Americans. Some of Mr. Austin's work was left in manuscript form, and all that he left is now in the writer's possession. Much of it consists of mere fragments or notes on a few species. A notable exception to this is the genus *Riccia*, on which his notes and descriptions are very complete; the account of that genus given here may be regarded as a condensation of Mr. Austin's manuscript notes. On the *Jungermaniaceæ*, the largest and most difficult order, Mr. Austin left almost nothing in manuscript.

In the preparation of this compilation the writer has made use of every available means for making it complete and authentic. Many thanks are due kind-hearted botanists for assistance; especial mention is due the following. To Prof. S. A. Forbes, for the loan of hepatic collections in the possession of the State Laboratory; to Prof. Sereno Watson for the generous loan of the manuscript on the Californian *Hepaticæ*, originally prepared for the "Botany of California," but not published; to Prof. Watson and the other authorities at Cambridge for access to the extensive libraries and collections; to Dr. H. A. Bolander and others for generous contributions of specimens particularly from the Pacific coast.

No attempt has been made to publish new species, the writer believing that too many have already been described from insufficient data, and considering it far more necessary to set in order those already published.

It is hoped that persons receiving this work will aid the further and critical study of this group by communicating specimens of all the forms found in their own localities.

SYRACUSE, N. Y., *November 10, 1883.*

INTRODUCTORY

General Characters. The HEPATICÆ include quite diverse forms of vegetation, judging from the outward habit of the plants composing the group, yet all are more or less intimately related in their essential, that is, their reproductive characters. The lower forms consist of a mere expansion of tissue with no differentiation of stem and leaves. These thalloid forms are quite frequently confused with certain forms of lichens, but can be easily distinguished by the fact that while the lichen is usually rather dry and crustaceous or leathery, the hepatic is more loosely cellular or spongy in texture, and presents a moist or somewhat juicy appearance under pressure. Some of the aquatic forms have also been mistaken for algæ. The higher forms of Hepaticæ are more moss-like in general appearance, consisting of a stem and leaves usually closely creeping over some substance, which may be the ground itself, rotten wood, living trees, or rocks. These higher forms are sometimes confused with the true mosses (*Musci*), but can usually be distinguished by having the leaves two-ranked, while the mosses proper have them in several or many ranks. The more technical differences will be made apparent at a later paragraph.

Habits of Growth. The Hepaticæ are as various in their habits of growth as they are diverse in their external appearance. They may be looked for in almost any situation, though certain conditions seem most favorable for continued and thrifty growth. Some may be found on the ground in ditches or in moist places, others grow on rocks or stones by brooks or rivulets, while others still are found on rotten logs or stumps in forest or swamp. Some species are found among other mosses, notably the *Sphagna* of swamps and peat-bogs,

some grow on the bark of living trees, a few on the stems or leaves of herbaceous plants, while at least one American species is found growing over lichens. Some grow in cultivated, even trodden ground, and a very few are aquatic in pools or ponds.

Size. The variation in size is often considerable; a few forms of *Lejeunia* are so small as to be almost invisible to the unaided eye; this condition, however, is not common, and most will measure from a few milllimetres to several centimetres in length. All forms are small and inconspicuous, and rarely are the species so crowded or numerous as to form a conspicuous portion of the earth's vegetation.

Time for Collecting. The hepatics should be collected for preservation and study when in fruit, if this be possible, and this condition occurs at different seasons in the various species; some bear fruit in late autumn, some in early spring, some in midsummer; in short, there is scarcely any season of the year, even winter, that will not find some form in fruit, yet the period from October to May may include the larger number of species for the cool temperate regions of America. Many species have never been found in fruit, and possibly never produce fruit, so it will be advisable to collect all species whether in fruit or not, for otherwise these less known forms may be neglected.

Geographic Distribution. Too little is known at present regarding the range of our native species to arrive at definite conclusions regarding distribution, yet certain preliminary features may be noted with even our present knowledge. Of the 231 species described in this paper 111 are common to North America and Europe. We may tabulate our species in five chief groups or natural divisions:

I. BOREAL: including those species found on the summits of the higher mountains of the Atlantic States as well as the Rocky Mountains of the West, and the colder portions of Canada, Labrador and Greenland; most of the species of this province are common to the colder portions of the Old World.

II. MEDIAL: including those species inhabiting that portion of the United States and Canada east of the Rocky Mountains not already included in I; more than one-half the species

we have in common with England and the lower latitudes of Continental Europe.

III. AUSTRAL: including the forms found in the southern border states from Texas or New Mexico to Florida, some forms being common to Mexico or the West Indies, or both, and a few found in Europe.

IV. OCCIDENTAL: including the Pacific border region from Lower California to British Columbia, and possibly to Alaska, including also the species of the Sierra Nevadas.

V. COSMOPOLITAN: including species more or less common to all portions of our territory, all of which are also common to Europe.

The above divisions are, of course, merely tentative, and may be considerably modified by a further knowledge of the distribution of individual species. (See Appendix A.)

Our species may be summed up as follows:

DIVISION.	Number of Species.	Peculiar to America.	In common with Europe.
I. BOREAL	38	10	28
II. MEDIAL	99	45	54
III. AUSTRAL	46	39	8
IV. OCCIDENTAL	34	27	7
V. COSMOPOLITAN	14	....	14
TOTAL	231	121	111

ESSENTIAL CHARACTERS

From this brief outline or introduction to the more general characters of the hepatics, we must now consider the special or characteristic habits of the group and its subdivisions. As the plants of this group all manifest two distinct phases in their cycle of growth or life history, it will become

necessary to consider each separately, as the *sexual phase*, and the *sporogony phase.*

Sexual Phase. All HEPATICÆ, in common with the MUSCI (Mosses), manifest what is called an "alternation of generations,"* which distinguishes them for the most part from the lower forms of plant life, and connects them with the ferns and their allies. The first phase is developed from the spore, either directly or indirectly, and produces the sexual organs by which the second or spore producing phase is orignated. As the sexual phase is the form in which the plant is most likely to be seen, and furnishes the most distinctive generic and specific characters, a detailed account of the various parts and organs will be first given.

Vegetation. Two principal forms of vegetation are commonly found in this group of plants, namely, the *thallose*,† consisting merely of an expanded or flattened mass of tissue, without distinction of stem and leaves; and the *foliaceous,* with well marked stem and leaves. These two forms, however, are only the extremes of a somewhat regularly graded series of forms. The entire series may be characterized as follows:

1. Forms consisting of a true thallus. *(Anthoceros, Aneura.)*

2. Thalloid stems, usually with scales underneath, which may correspond to leaves. *(Marchantia, Blasia.)*

3. Pseudo-foliaceous forms, in which the thallus is lobed, the lobes assuming leaf-like forms. *(Fossombronia.)*

4. Typical foliaceous forms. *(Jungermania, Frullania.)*

The vegetation in all Hepaticæ is bilateral, that is, differently developed on the upper and under sides. The under side, deprived of the light, differs in internal structure from the upper, and there frequently results a corresponding difference in the external appearance. Most are of some shade of green, the darker more common, but varying to brownish-green and even fuscous; some of the thallose forms are purplish beneath,

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* I have hitherto pointed out the misapplication of this term, which must eventually give place to one more exact and scientific. Compare: *Our Native Ferns and Their Allies*, p. 35, note.

† *Frondose* is an older term, but the term *frond* has an entirely different signification, and is appropriately applied to the ferns; the above term is moreover more expressive and exact.

and this frequently extends to the upper margins, and more rarely to the entire upper surface. Some species of *Riccia* are whitish, or even milky white, above.

True roots are never present, but root-hairs, consisting ordinarily of a single cell, are usually abundantly produced on the under surface of the thallus, or, in the foliaceous forms, may proceed from definite points of the leaves (*Radula*), or the amphigastria (*Frullania, Madotheca*), or, as in most, from the under side of the stem, or from both stem and leaves (*Jungermania crenulata*). In those forms that live on dry rocks and the bark of trees, the root-hairs are short and fascicled, and are sometimes provided with a sucker-like development at the end. The cell composing the root-hair is usually, in the thallose forms, granulose or papillose on the inner surface of its wall.

Thallus. The thallus is usually dichotomously branched, less frequently somewhat pinnately branched, and in rare cases simple. In some forms it is conspicuously reticulate on the upper surface, and is further marked with large whitish pores (*Conocephalus*).

Leaves. In the foliaceous forms the leaves are usually two-ranked (*distichous*), with frequently a rudimentary row on the ventral surface, known as the *amphigastria* (Gr. *amphi*, about, and *gastrion*, diminutive of *gaster*, belly). Both leaves and amphigastria may be entire, serrate, dentate, or variously lobed, cleft or divided. When one of the lobes is much inflated (*Frullania*) it is termed an *auricle*. The amphigastria usually differ from the leaves more or less in size and shape, though in rare cases they are similar, and the leaves thus become apparently three-ranked.*

Asexual Reproduction. This occurs among the hepatics under three forms: viz: (1). By innovations. (2). By gemmæ. (3). By runners.

In nearly all hepatics, except those that are annuals, the growth is continuous and indefinite from the apex of the stems or branches by a process of renewal, while the older portion

* Is it possible that the 3-ranked condition is the typical form, and that the amphigastria represent the abortive condition resulting from their position on the ventral surface? If so, this would be a marked example of retrograde development.

gradually dies away; the branches thus become independent plants by a sort of compulsory self-division. By this method large areas become covered with a single species without the production of spores.

Gemmæ (Lat. *gemma*, a bud) are variously produced in different genera. In some *(Madotheca)* they are simuly cells detached from the margin of the leaves; in others *(Marchantia)* they are produced in broad cup-shaped receptacles on the upper side of the thallus, looking like miniature bird's nests with their included eggs; in other genera the receptacle may be flask-shaped *(Blasia)*, or crescent-shaped *(Lunularia)*. The last-named species may be seen in almost any greenhouse, where it has been introduced from Europe, and the crescent-shaped gemmæ cups are found on nearly every plant. Many species produce no gemmæ.

Less commonly the Hepaticæ multiply by runners, a peculiar form of which is termed a *flagellum* (Lat. a lash). Tubers, so called, were once supposed to form a fourth method of reproduction, but these "endogenous gemmæ" have been found to be produced from filaments of *Nostoc*. They are most common in some species of *Anthoceros*.

Sexual Organs. Two kinds are present, known respectively as *archegonia* (Gr. *archa*, beginning, and *gonos*, seed), analogous to pistils, and *antheridia* (Lat. *anthera*, an anther, and Gr. *eidos*, form), analogous to stamens. The relative position of these organs on the plant varies greatly in different genera. When the sexual organs are in the same cluster the term *synœcious* (Gr. *sun*, together, and *oikia*, house) is used; this form, however, rarely, if ever, occurs among the hepatics. When the antheridia are situated in the axils of bracts near the archegonia, or when (as in *Fossombronia*) both organs are naked on the dorsal surface of the same stem, the relation is said to be *parœcious* (Gr. *para*, beside, and *oikia*). When the antheridia occur in a separate receptacle on the same plant as the archegonia, the plant is *monœcious;* the same arrangement, but with the sexes on separate plants, is the *diœcious* relation. In some species one or more relations exist, apparently without special reason.

Antheridium. The male organ is usually globose or oval

and raised on a pedicle in the foliaceous species; in the thallose species it may be sessile on the surface of the thallus (*Sphærocarpus*), immersed in it (*Fimbriaria*, *Pellia*), or in a sessile or pedunculate disc-like receptacle, sometimes called an *androcephalum* (*Marchantia*, *Asterella*). The antheridia collectively are sometimes referred to as the *andræcium*.

The antheridia contain a large number of small bodies suspended in a mucus, which consist essentially of spirally curved slender threads, provided at the end with cilia for purposes of motion; these are the antherozoids (Lat. *anthera*, anther, Gr. *zoon*, an animal, and *eidos*, form), and are analogous to pollen.

Archegonium. The female organ is a flask-shaped body which, when mature, has an orifice at the apex opening into the interior, where is found a globular cell known as the *oosphere* (Gr. *oon*, an egg, and *sphairos*, a sphere).

The process of fertilization consists of a union or conjunction of the antherozoid produced from the male organ, and the oosphere produced by the female, an end made possible by the motile power of the former. The fertilized oosphere developes into the "alternate generation," or sporogony phase.

In most of the true Liverworts (MARCHANTIACEÆ) the archegonia are situated on the under side of a usually peduncled receptacle, which, as it bears the so-called fruit, is known as the *carpocephalum* (Gr. *karpos*, fruit, *kephale*, head).

Involucres. Immediately surrounding the archegonia, and usually formed after fertilization takes place, is a tubular or somewhat prismatic organ, which may be called the *inner involucre*;* surrounding this is the *outer involucre*,* which is

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* I have used the above terms at the suggestion of Dr. Gray, notwithstanding the different use of writers in both Europe and America. American writers have largely followed Nees von Esenbeck, in *Synopsis Hepaticarum* (1844), while recent European writers have revived the nomenclature of Dumortier, used as early as the publication of *Sylloge Jungermannidearum* (1831), and perhaps earlier. It would seem that a rearrangement of terms, adjusted to both *Musci* and *Hepaticæ*, might profitably be made. That no error be made by those referring to other writers, the following comparison is given:—

Inner involucre (as above) = colesula (*Dumortier*, *Lindberg*) = perianth (*Nees von Esenbeck*, *Sullivant*, *Austin*) = perichætium (*Ekart*).

Outer involucre (as above) or simply *involucre* = perichætium (*Dumortier*, *Lindberg*) = involucre (*Nees von Esenbeck*, *Sullivant*, *Austin*) = calyx (*Ekart*).

tubular *(gamophyllous)*, or composed of separate leaves of peculiar shape, then called *involucral leaves (polyphyllous)*. In *Fossombronia* the archegonia are naked on the dorsal surface of the thallus, there being no involucres, and in several genera either the outer or inner involucre may be absent.

Sporogony Phase. The so-called "fructification," or "asexual generation," is properly neither, but merely a phase or stage of growth in the life-history of the plant, as the caterpillar is a mere phase in the life-history of a butterfly. It may be called the *sporogony phase* (Gr. *sporos*, seed, and *goneia*, generation). This varies slightly in the various orders, but essentially consists of a *capsule* containing the *spores* and, with the exception of the Order RICCIACEÆ, *elaters*, whose function is to aid in distributing or scattering the spores. The capsule, with its appendages, constitutes the *sporogonium*, and consists of an elongate, two-valved, projecting pod in *Anthoceros;* a thin-walled ball sessile on the thallus or sunken in its tissue in *Riccia;* a short-stalked ball in *Marchantia*, and a more or less long-stalked ball in *Jungermania*, the four named genera each forming the type of an order. In *Targionia* the capsule is situated in a bivalved receptacle beneath the apex of the thallus. Altho the sporogonium appears like an outgrowth of the mature sexual plant, it nowhere unites with the surrounding vegetative structure, even when its pedicel penetrates into its tissue.

Calyptra. In the course of the development of the sporogonium the lower portion, which has become considerably expanded, separates into two portions, the outer called the *calyptra* (Lat. a covering for the head), which is ultimately of a thin and delicate texture, and closely invests the capsule formed of the inner portion. The upper portion of the archegonium not expanding, forms a blunt point, which crowns the calyptra, and is called the *style*.

Spores. The product of this phase is the spores, which are developed in fours in a sort of globular utriculus, which disappears when the spores mature and allows the spores to separate. In some of the RICCIACEÆ the spores remain united and form a *coccus* or berry.

The surface of the spores may be smooth, reticulate, papillose or granulose. The spores on germinating produce the sexual phase.

Elaters. Enclosed in the capsule with the spores are certain thread-like bodies formed of a single cell, and containing from one to four spiral (rarely annular) bands in their walls. These are the *elaters*, and probably aid in scattering the spores when the capsule matures and its valves separate. In *Anthoceros* they are often of peculiar shape, simple or jointed, and usually without distinct fibres.

In the last named genus occurs another organ known as the *columella*, which is found in no other group of *Hepaticæ*, but reappears as a constant organ in the true mosses.

CLASSIFICATION

General Relations. The hepatics form a part of a natural group of plants which stands about midway between the highest and lowest forms of vegetable life. Indeed, in them are mingled forms representing the two vegetative types — the one *thallophytic*, with merely a plant body without true foliage — the other *cormophytic*, having the differentiation of stem and leaves more or less complete.

In the seven recognized divisions of the vegetable kingdom the *Bryophyta*, to which the hepatics belong, is placed fifth in a lineal classification, as follows:—

I. PROTOPHYTA.—Bacteria, yeast plant, etc.
II. ZYGOSPORA.—Diatoms, desmids, moulds, etc.
III. OOSPORA.—Many freshwater and marine algæ.
IV. CARPOSPORA.—Red algæ, *Chara*, lichens, mushrooms, many parasitic fungi.
V. BRYOPHYTA.—Hepaticæ, mosses.
VI. PTERIDOPHYTA.—Ferns and their allies.
VII. PHANEROGAMIA.—Flowering plants.

A lineal classification, however, does not properly present the natural position or inter-relations of the Hepaticæ and other groups, and indeed the affinities of the lower groups are too imperfectly understood to represent even a tolerable natural

that is to say, *genetic* relationship. A creditable attempt is made by Prof. Bessey in his excellent Botany (p. 568) to arrange the primary divisions with reference to descent. It was a fancy of Mr. Austin, expressed in his MSS., as well as hinted in his publications,* that the hepatics were only a higher development of some form of freshwater algæ, and that the ferns, in turn, were a higher development of the hepatics. In a generalized sense this is likely to prove nearer the realm of fact than that of fancy. Unfortunately few of the earlier forms have been preserved in a fossil state to offer a clue to the affinities of primordial types.

Relation to Mosses. Whatever be the origin of the members of this group, or however the earlier representatives may have been allied to lower forms, the hepatics with the true mosses (*Musci*) at present form a somewhat specialized group, clearly marked in their methods of growth as well as in their reproductive characters. These two were early associated together in a sub-class known as "Cellular Acrogens," but are now more explicitly and appropriately named the *Bryophyta* (Gr. *bruon*, moss, *phuton*, plant), i. e., mosses and their allies.

The distinguishing characteristics of the two allied groups may be brought out more clearly by the following parallel arrangement:—

HEPATICÆ.	MUSCI.
1. *Plant body* varying (in different species) from a thallus to a leafy axis.	1. *Plant body* always a leafy axis.
2. *Stems* bilateral, consisting of an upper and a lower side distinct in appearance and structure.	2. *Stems* not bilateral, uniformly developed.
3. *Leaves* 2-ranked, often with rudiments of a third (*amphigastria*), never with a midvein.	3. *Leaves* 3-many (sometimes 2-), ranked usually with a midvein.
4. *Root hairs* unicellular.	4. *Root hairs* usually composed of a row of cells.

* Bulletin Torrey Botanical Club, VI, 306.

Hepaticæ.	Musci.
5. *Calyptra* remaining below at the base of the capsule which ruptures its upper portion.	5. *Calyptra* ruptured at the base by the capsule, which it covers as a cap.
6. *Capsule* maturing before rupturing the calyptra, opening by 2 or 4 valves, or irregularly; or indehiscent, never by a special lid.	6. *Capsule* maturing after rupturing the calyptra, opening by a special lid (*operculum*).
7. *Columella* wanting (except in *Anthocerotaceæ*).	7. *Columella* always present (at least at an early stage of development).
8. *Elaters* mixed with the spores (except in *Ricciaceæ*).	8. *Elaters* never present.

In other characters the two groups closely resemble each other.

Subdivisions. The hepatics, varying so much in their characters, may be arranged in four or five well-marked groups, four of which it would seem should rank as *orders*, notwithstanding the rearrangement of recent European writers.*

These four are all largely represented among our forms and each is of somewhat general distribution. Their characters may be arranged in tabular form for convenience of comparison:

* Compare S. O. Lindberg *Genera Europaea Hepaticarum secundum novam dispositionem naturalem.* In Acta Soc. Fenn. X. That Lindberg's classification may be more widely known in this country a tabulated outline will be found in Appendix B.

	RICCIACEÆ.	MARCHANTIACEÆ.	ANTHOCEROTACEÆ.	JUNGERMANIACEÆ.
PLANT BODY	A thallus dichotomously branching, usually scaly beneath.	A thallus dichotomously or radiately branching, scaly beneath.	A thallus irregularly branching.	In a few forms a thallus variously branching; in most a leafy axis with two rows of leaves and sometimes a rudimentary third row beneath.
EPIDERMIS	Usually distinct, eporose.	Well marked, usually porose.	Wanting.	Wanting (leaves composed of a single layer of cells.)
CAPSULE	Spherical, immersed in thallus or sessile on its surface, *indehiscent*.	Spherical, short-stalked, opening irregularly or by imperfect valves, frequently pendent from under surface of a receptacle (*carpocephalum*).	Elongate, two-valved at maturity.	Usually spherical and long-stalked, opening by four valves.
ELATERS	Wanting.	Present, with spiral fibres.	Present, lacking spiral fibres.	Present, with spiral fibres.
COLUMELLA	Wanting.	Wanting.	Present.	Wanting.
Number of American Genera	3	13	2	32

Popular names have been only rarely applied to the hepatics because of their humble and inconspicuous position in the vegetable world, yet the *Ricciaceæ* are sometimes known as Crystalworts, the *Marchantiaceæ* as Liverworts, the *Anthocerotaceæ* as Horned Liverworts, or simply Hornworts, and the *Jungermaniaceæ* as Scale Mosses. The old name of the common *Marchantia polymorpha* — Liverwort — given since it was supposed to be a specific for liver troubles, because the thallus bore a faint resemblance to the liver — has been latterly adopted for the entire order, and in a Latin form (*Hepaticæ*) for the entire group. Thus does the language of ignorant superstition become the adopted language of science.

BIBLIOGRAPHY

The works consulted in the preparation of this paper, not including various general works on Botany, are given below. The list is believed to contain all American works, as well as papers and notes in American periodical literature. Notices of any omissions in this particular would be thankfully received. The only works hitherto professing to describe the American species of any considerable area are those by Schweinitz (1821) and Sullivant (1856). It is hoped that a critical work, figuring the rarer American forms, may follow this introductory paper in due course of time.

AUSTIN (Coe F.) Characters of some new Hepaticæ (mostly North American) together with Notes on a few imperfectly described Species. In Pro. Phil. Acad., Dec. 1869 (Vol. —, pp. 218–234). Describes 39 new species as follows: from the U. S. 24; from Sandwich Is. 9; from Japan 3; from Mauritius 2; from Nepal 1.

——New Hepaticæ. In Bull. Torr. Bot. Club, Mar. 1872 (Vol. III, pp. 9–18). Describes 17 new species as follows: from the U. S. 15; from Europe 1; from Fiji Is. 1.

———Hepaticæ Boreali-Americanæ Exsiccatæ. 1873. Specimens of 176 species and varieties of American Hepaticæ (Nos. 1–150 with 26 interpolated numbers). The tickets of the specimens were also published in pamphlet form.

———Sandwich Island Hepaticæ. In Bull. Torr. Bot. Club, Mar. and Apr. 1874 (Vol. V, pp. 14–18.) Two lists, one of 24, the other of 34 species, with descriptions of 13 new species.

———New Hepaticæ. In Bull. Torr. Bot. Club, Mar. 1875 (Vol. VI, pp. 17–21). Describes 13 new species as follows: from the U. S. 11; from Cuba 1; from Africa 1.

———Notes on the Anthocerotaceæ of North America, with descriptions of several new species. In Bull. Torr. Bot. Club, Apr. 1875 (Vol. VI, pp. 25–29). Describes 9 new species.

———Notes on the Genus Pellia. In Bull. Torr. Bot. Club, Apr. 1875 (Vol. VI. pp. 29–30).

———New Hepaticæ. In Bull. Torr. Bot. Club, July 1875 (Vol. VI, pp. 46–47). Describes 3 new species, 1 each from California, Lower California and Van Dieman's Land.

———Notes and Criticisms on Hepaticæ Americanæ Exsiccatæ. In Bull. Torr. Bot. Club, Apr. 1876 (Vol. VI, p. 85.) The notes are on Nos. 6, 15, 19, 20, 26, 27, 29, 29b, 30, 31 and 35.

———Notes on Hepaticology. In Bot. Bulletin (now Bot. Gazette), May and June 1876 (Vol. I, pp. 31–32, 35–36). Describes 11 new species as follows: from the U. S. 5; from Sandwish Is. 4; from Cuba 1; from Jamaica 1.

———New Hepaticæ. In Bull. Torr. Bot. Club, June 1877 (Vol. VI, pp. 157–158). Describes 4 new species, 3 from the U. S. and 1 from Mexico.

———Notes. In Bot. Gazette, Oct. 1877 (Vol. II, p. 142). *Lejeunia biseriata?* changed to *Erpodium biseriatum?*

———List of 15 species of Hepaticæ from Colorado and the Southwest. In Vol. VI, Botany; U. S. Geog. Surveys west of the 100th meridian, 1877.

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——Notes on Hepaticology. In Bull. Torr. Bot. Club, Apr. 1879 (Vol. VI, pp. 301-306). Describes 10 new species as follows: from the U. S. 5; from Sandwich Is. 3; from Japan, Chili and Australia, each 1.*

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——Same. In "Catalogue of the Plants of Ohio." 1874.

BOLANDER (Henry N.) List of 30 species of Hepaticæ growing in California. In "A Catalogue of the Plants growing in the Vicinity of San Francisco." 1870.

BORY DE SAINT VINCENT et **MONTAGNE** (C.) Sur un Nouveau Genre de la Famille des Hepatiques. In Annals Sciences Naturelles, Apr. 1844.

BRENDEL (Friedrich). Flora Peoriana: Die Vegetation im Clima von Mittel-Illinois. Budapest, 1882. List of 19 species of *Hepaticæ* growing in the vicinity of Peoria, Illinois.

DUMORTIER (Barth. Car.) Sylloge Jungermannidearum Europæ Indigenarum, 1831.

——Recueil d'observations sur les Jungermanniacees, 1835.

——Hepaticæ Europæ, 1874. The European Manual of the Hepaticæ, describing, with synoptic tables, all the recognized species of Europe.

EKART (Tobia P.) Synopsis Jungermanniarum in Germania Vicinisque Terris Hucusque Cognitarum, 1832. Illustrated with 116 well-executed figures showing the microscopic characters of the order *Jungermaniaceæ*.

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* It may be of interest to summarize the work of Mr. Austin in the Hepaticæ as by him, more than any other American botanist, has the subject of this perplexing but interesting group been brought to its present condition. Total number of new species described 122, distributed as follows: United States, Canada and British Columbia, 74; Sandwich Islands 30; Japan 4; Mauritius, Mexico and Cuba, each 2; Jamaica, Chili, Europe, Africa, Australia, Van Dieman's Land, Figi Islands and Nepal, each 1.

2

GOTTSCHE (Carl M.) Ueber die Fructification der Jungermanniæ Geocalyceæ, 1844.

———De Mexikanske Levermosser, 1863.

HITCHCOCK (Edward). List of 24 species of Hepaticæ growing in Massachusetts. In "Catalogue of Plants growing without cultivation in Massachusetts." Report on Geol. etc., of Mass. 1834.

HOOKER (William Jackson). British Jungermanniæ. 1816. This magnificent volume is most valuable on account of the 88 accurately figured and colored plates which it contains.

LEHMAN (J. G. C.) Pugillus Novarum et Minus Cognitarum Stirpium. IV, V, VI, VII, VIII and X on Hepaticæ.

LEITGEB (Hubert). Untersuchungen ueber die Lebermoose. 1874–9.

LINDBERG (S. O.) Hepaticæ in Hibernia Mense Julii, 1873, lectæ. In Acta Soc. Scien. Fennicæ X, 1875, pp. 467–559.

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LINDENBERG (J. B. G.) Monographie des Riccieen, 1836.

———Synopsis Hepaticarum Europæarum. 1829.

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NEES VON ESENBECK (Christian Gottfried). Naturgeschichte der Europäischen Lebermoose. 1833–1838. 4 Bændchen.

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ROBINSON (John). List of species of Hepaticæ in Essex Co. (Mass.) In "Flora of Essex County." 1880.

ROTHROCK (J. T.) Flora of Alaska. In Smithsonian Report, 1867. List of 6 species of *Hepaticæ.*

RUSSELL (J. L.) Hepatic Mosses of Massachusetts. In Boston Jour. Nat. History, Vol. III.

SCHWEINITZ (Lewis David de). Specimen Floræ Americanæ Septentrionalis Cryptogamicæ sistens Mucos Hepaticos huc usque in Amer. Sept. Observatos, 1821. Describes 77 species of American Hepaticæ.

SULLIVANT (William S.) Musci Alleghanienses, 1846. Of this series Nos. 216-292 — seventy-six numbers — are Hepaticæ. The tickets are also collected in book form and contain many notes on the specimens.

———Contributions to the Bryology and Hepaticology of North America. Part I (3 plates). In Memoirs Amer. Acad. (new series) III. Part II (1 plate). In same (new series) IV. Descriptions of 5 new species and notes on several others.

———Musci and Hepaticæ of the Eastern United States. 1856. Describes the Hepaticæ of the Eastern U. S., as then known; giving 3 copperplates illustrating the genera.

———Descriptions of *Musci* and *Hepaticæ* collected on the Pacific R. R. Survey. In Vol. IV of the Report. List of 7 species of *Hepaticæ.*

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WARD (Lester F.) Guide to the Flora of Washington [D. C.] and Vicinity. 1881. List of 29 species of *Hepaticæ.*

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Descriptive Catalog

CLASS HEPATICÆ

Small moss-like or thalloid plants of a lax cellular texture, usually procumbent and emitting rootlets from beneath. Calyptra usually rupturing at the apex. Capsule irregularly dehiscent, bivalved, quadrivalved, quadridentate, or indehiscent, containing spores mixed with thin thread-like cells, usually containing one or more spiral fibres *(elaters)*. Reproductive organs of two kinds, variously situated, the matured archegonium forming the capsule. Columella rarely present. The calyptra with its enclosed capsule is usually surrounded by a tubular inner involucre, which in turn is surrounded by a tubular outward involucre or by involucral leaves. The calyptra is always present: either involucre or both may be absent.

ARTIFICIAL SYNOPSIS OF ORDERS

A
- Vegetation thallose . . . . B
- Vegetation foliaceous; capsule quadrivalved or quadridentate. Order IV. JUNGERMANIACEÆ *(foliosæ* Gen. 6–32).

B
- Capsule indehiscent, elaters wanting. Order I. RICCIACEÆ.
- Capsule irregularly dehiscent, borne on the under side of a pedunculate receptacle. Order II. MARCHANTIACEÆ.
- Capsule bivalved C
- Capsule quadrivalved. Order IV. JUNGERMANIACEÆ *(thallosæ* Gen. 1–6).

C { Capsule more or less peduncled, columella present. Order III. ANTHOCEROTACEÆ.
Capsule sessile; columella wanting; *Targionia* in Order IV. MARCHANTIACEÆ.

In the following pages no attempt has been made at a complete bibliography or synonymy. References are made to Syn. Hep. Gottsche, Lindenberg, and Nees' *Synopsis Hepaticarum*, 1844, and Hep. Europ. Dumortier's *Hepaticæ Europa*, 1874, where a more complete synonymy may be found. For figures reference is to Brit. Jung. Hooker's *British Jungermanniæ*, 1816, and Ekart Ekart's *Synopsis Jungermanniarum Germanicarum*, 1832.

ORDER I. RICCIACÆ ENDL.

Terrestrial or pseudo-aquatic, chiefly annual plants with thallose vegetation. Fruit short-pedicelled or sessile on the thallus or immersed in it. Calyptra crowned with a more or less deciduous colored style. Capsule either free or connate with the calyptra, globose, at length rupturing irregularly. Spores usually angular, reticulate or muriculate. Elaters wanting. Antheridia ovate, immersed in the thallus in flask-shaped cavities with protruding mouths (ostioles). Thalli with or without areolæ and air cavities.

SYNOPSIS OF GENERA

A { Spores separate; fruit immersed in the thallus. I. RICCIA.
Spores in fours, united in a coccus or berry — B.

B { Fruit immersed in the substance of the thallus. II. THALLOCARPUS.
Fruit aggregated, sessile on the thallus. III. SPHÆROCARPUS.

I. RICCIA MICH.

Fruit immersed in the thallus, sessile. Calyptra with a persistent style. Capsule sessile within the calyptra. Spores alveolate or muriculate, flattish and angular (except in *R.*

tenuis). Thallus at first radiately divided from the centre, which often soon decays; the divisions bifid or di-trichotomous, plane, depressed or canaliculate above, and usually convex and naked or squamulose beneath; margins either naked or spinulose-ciliate. Epidermis usually distinct, eporose; air cavities evident in some species, wanting in others. Rootlets papillose within (except in *R. Frostii*). Named for *Ricci*, an Italian botanist.

§ 1. LICHENODES Bisch. *Thallus solid, without air cavities; fruit mostly protuberant above; spores about 0.084 mm. in diameter, angular, issuing through openings which at length appear in the upper surface of the thallus.* Terrestrial species growing on damp, usually trodden or cultivated ground, and closely adhering to it.

* *Thallus naked on the margins or underneath (without cilia or scales).*

1. **R. Frostii** Aust. Thallus orbicular, 1.3—2.5 cm. in diameter, subsolid, thinnish, subpalmately or radiately divided, cinereous-green, fibrously reticulate, minutely pitted and either plane or channeled above, concolorous or *tinged with purple toward the apex beneath*, very narrowly membranous, somewhat papillose-squamulose, and *often tinged with purple on the margin;* divisions linear or subspatulate-linear, subdichotomous; lobes subtruncate and indistinctly emarginate; *rootlets smooth* or obsoletely papillose within; capsules irregularly disposed, very prominent underneath; spores nearly round, barely 0.051 mm. in diameter, fuscous, somewhat margined, minutely and obscurely reticulated and granulose-papillose, *the sides strongly depressed when dry.*

Hab.—Nev. (*Watson*), Col. (*Wolfe*), O. (*Beardslee*), Ill. (*Hall*).
Bib.—Torrey Bull. VI, p. 17.

2. **R. Watsoni** Aust. Diœcious; thallus of male *plant small, fuscous-purple both sides*, orbicular, deeply and many times divided, thick, fleshy, *broadly pitted*, papillose, fibrous-reticulate and *with rather large, terete subclavate, gland-like papillæ* (ostioles?) *above*, densely radiculose and nodulose be-

neath; divisions narrow, dichotomous, plane or when dry broadly canaliculate above, convex-thickened beneath; lobes nearly linear, very obtuse, narrowly emarginate and somewhat thickened at the apex; rootlets smooth within; antheridia large, immersed, causing the under surface to appear nodulose. Possibly only the male plant of No. 1.

Hab.—Nev. (*Watson*), Col. (*Wolfe*).
Bib.—Torrey Bull. VI, p. 17.

3. **R. glauca** L. Thallus orbicular, somewhat stellately lobed, 1.3–2.5 cm. in diameter; divisions linear-obovate or linear-obcordate, emarginate-lobed, channeled only toward the apex, *beautifully reticulate and glaucous above*, membranous along the margin, greenish beneath; spores 0.084 mm. in diameter, moderately reticulate and with a narrow pellucid margin.

Hab.—Cal. (*Bolander*). (Eu.)
Bib.—Syn. Hep. p. 599, Hep. Europ. p. 167.
Delin.—Lindenberg Monog. Ric. t. XIX.

4. **R. albida** Sulliv. in Herb. 1853. Thallus small, covered with *a thick, spongy, deeply-pitted, milk-white epidermis*, alternately or bifurcately divided; divisions oblong, much crowded, with a rounded sub-marginate apex, narrowly and deeply canaliculate above, densely radiculose and subsquamous beneath; fruit unknown.

Hab.—Tex. (*Wright*).
Bib.—Pro. Phil. Acad. 1869, p. 231.

5. **R. Beyrichiana** Hampe. MS. Thallus fleshy, cæspitose, adhering to the earth by long hyaline rootlets, sensibly dilated from a narrow linear base, mostly bifid $\frac{1}{3}$ the length, narrowly channeled and green above, the margins entire, ascending. Clothed with a dark-purple membrane beneath.

Hab.—"Between Jefferson and Gainsville, Tenn." (*Beyrich*).
Bib.—Syn. Hep. p. 601.

6. **R. bifurca** Hoffm. Thallus dichotomously or substellately divided, pale green; divisions wedge-shaped, 2-lobed at the apex; lobes spreading, dotted, broadly channeled above by the thick and ascending margins, purplish beneath.

Hab.—North America (*Synopsis Hepat.* p. 600). (Eu.) Doubtfully belonging to America.

Bib.—Syn. Hepat. p. 600, Hep. Europ. p. 167.

Delin.—Lindenberg Monog. Ric. t. XX.

** *Thallus naked on the margins, squamous underneath.*
† *Scales whitish.*

7. **R. Sorocarpa** Bisch. Thallus 0.6—1.9 cm. in diameter, pale green, or in the dry state or with age becoming albescent, *finely reticulate above*, subradiately or bifurcately divided; divisions oblong-linear, acutish, deeply and acutely sulcate above, much thickened beneath and furnished toward the apex with a few inconspicuous *white scales which do not extend beyond the margin;* margins erect, when dry; spores issuing through chinks which early appear along the groove above.

Hab—Thin rocky soil and cultivated fields; Closter, N. J. (*Austin*), Western N.Y. (*Clinton*), Ill. (*Hall*), Cal. (*Bolander*), S.C. (*Ravenel*). (Eu.)

Bib.—Syn. Hep. p. 600, Hep. Europ. p. 167.

Exsic.—Hep. Bor.-Amer. No. 139.

8. **R. lamellosa** Raddi. Thallus pale green, elegantly reticulated above, subradiately divided; divisions obovate or obcordate, bifid or bilobed, 0.4—1.1 cm. long, canaliculate at apex; margins membranous, ascending; furnished *beneath with white, transverse, subundulate scales which extend considerably beyond the margin;* fruit as in *R. Sorocarpa* with which it is usually associated.

Hab.—Thin rocky soil; Closter, N.J. (*Austin*), Cal. (*Bolander*). (Eu.)

Bib.—Syn. Hep. p. 605, Hep. Europ. p. 169.

Delin.—Lindenberg Monog. Ric. t. XXX.

Exsic.—Hep. Bor.-Amer. No. 140.

†† *Scales dark purple.*

9. **R. nigrella** D.C. Thallus dichotomously divided; divisions linear, canaliculate, with entire, narrowly membranous margins, green above, *dark purple beneath and furnished with transverse, semi-circular scales of the same color,* which do not exceed the margin.

Hab.—Rocky ground; N. Y. (*Torrey*), Chester, Pa. (*Porter*), Cal. (*Bolander*). (Eu.)

Bib.—Syn. Hep. p. 605, Hep. Europ. p. 170.

Delin.—Lindenberg Monog. Ric. t. XXIX.

Exsic.—Hep. Bor.-Amer. No. 140 b.

*** *Thallus more or less ciliate on the margins, naked or obsoletely squamous along the extreme edge underneath; usually with a purple spot in the epidermis immediately over the fruit.*

10. **R. arvensis** Aust. Thallus always orbicular, radiately much divided, 0.6—1.8 cm. in diameter, *dull green both sides*, papillose-reticulate and becoming fuscous above: margins plane, entire, acute or apparently thickened, becoming purple by age; divisions often crowded, somewhat dilated above from a common base, dichotomous, distinctly sulcate, carinate-thickened especially toward the apex, nodulose beneath; lobes linear-elliptic or subspatulate, *acutish and obsoletely emarginate at the apex;* cilia white, very short or often papilla-like and inconspicuous; fruit aggregated beneath the canal chiefly toward the apex of the lobes; spores about 0.071—0.084 mm. in diameter, dark fuscous, slightly pellucid, distinctly reticulate, with a conspicuous pellucid margin.

Var. **hirta** Aust. Thallus decidedly ciliate on the margin, and with spine-like hairs scattered over the whole upper surface, at length purple and more or less squamigerous beneath, somewhat glaucous and reticulate above; divisions broader, more obtuse, becoming thin and strongly canaliculate or often convolute on drying; spores nearly black, larger, 0.084—0.101 mm. in diameter, opaque, very indistinctly reticulate, and obscurely papillose, obscurely if at all margined.

Hab.—Rocky ground and cultivated fields; Closter, N. J. (*Austin*). The var. in similar locations.

Bib.—Pro. Phil. Acad. 1869, p. 232.

Exsic.—Hep. Bor.-Amer. Nos. 141, 142.

11. **R. Lescuriana** Aust. Monœcious; thallus stellately or somewhat cruciately divided; divisions bilobed or di-trichotomous, obcordate or cuneate-linear, 0.4—1.3 cm. long, punctate-reticulate, somewhat glaucous or cinereous green and slightly

depressed-canaliculate above, convex and green or at length purple beneath; margins usually purple, thickened, sub-ascending, *hirsute-ciliate, with crowded*, short, thick, obtuse, *white, spine-like hairs*, obsolete in young states; fruit sparse, scattered chiefly near the base of the divisions; spores about 0.071—0.083 mm. in diameter, dark brown, reticulate, not margined.

Hab.—Cultivated fields and rocky ground; N. J. to Ill. and Fla.
Bib.—Pro. Phil. Acad. 1869, p. 232.
Exsic.—Hep. Bor.-Amer. No. 143.

12. **R. Californica** Aust. MS. Divisions of thallus expanded at apex, obcordate, cuneate, ciliate only at or toward the apex or sometimes almost entirely naked on the margins; spores as in *R. Lescuriana* which this species resembles.

Hab.—Cal. (*Bolander*).
Bib.—Torrey Bull. VI, p. 46.

13. **R. ciliata** Hoffm. Thallus dichotomously or substellately divided; divisions linear or cuneate, obtuse, subemarginate, subcanaliculate at the apex; cilia very long, slender and fuscous, spores about as in *R. Lescuriana*.

Hab.—With *Fossombronia longiseta* from Cal. (*Bigelow*). (Eu.)
Bib.—Syn. Hep. p. 602, Hep. Europ. p. 168.
Delin.—Lindenberg Monog. Ric. t. XXIII.

14. **R. intumescens** Bisch. Thallus bifurcately lobed: lobes very tumid, subcuneate-linear or subcuneate-oblong, deeply and narrowly canaliculate, cinereous green, reticulate only in the groove, which does not occupy more than $\frac{1}{3}$ of the apparent upper surface, *very dark purple (almost black) beneath*, emitting rootlets only along the middle: the whole surface of the thickened and strongly inflexed *margins densely clothed with long, appressed, white, slender, spine-like hairs, which in the dry state meet over the groove and entirely conceal it;* spores brown, very finely reticulated, not margined. (*R. tumida* Lindenb.)

Hab.—Rocky ground; Cal. (*Bolander*). (Eu.)
Bib.—Syn. Hep. p. 603, Hep. Europ. p. 169.
Delin.—Lindenberg Monog. Ric. t. XXVII.
Exsic.—Hep. Bor.-Amer. No. 143 b.

**** *Thallus squamous beneath, squamous or squamous-ciliate on the margin, with a distinct costa.*

15. **R. Donnellii** Aust. Diœcious; primary thallus orbicular, large, often 3.8 cm. in diameter, substellately divided, nearly plane, elegantly and grossly cristate-reticulate above, pale green both sides; divisions more or less di-trichotomous, often deeply channeled when dry, emarginate at the apex; fruit in a single row, immersed in the midrib; spores very large 0.127–0.168 mm. in diameter, subrotund, black, opaque, subtuberculate; male thallus usually a little larger; ostioles numerous, filiform, hyaline, 1 mm. high.

Hab.—Gardens and cattle-ranges; Fla. (*J. Donnell Smith*).

Bib.—Torrey Bull. VI, p. 157.

§ 2. Spongodes. *Thallus with large air-cavities and with a slight depression in the upper surface immediately over the fruit which is prominent on the under surface; upper surface usually broken up into pits communicating with the air-cavities; spores smaller 0.041—0.051 mm. in diameter, obtusely angular or globose.* Pseudo-aquatic or occurring on wet or muddy ground.

* *Thalli homomorphous, terrestrial.*

16. **R. crystallina** L. Thallus orbicular, 1—2 cm. in diameter; divisions obcordate or cuneate, bifid or bilobed, plane above, the margins subcrenate, the upper surface much broken up into pits; fruit scattered; spores issuing through the upper surface. (*R. plana* Tayl., *R. velutina* Hook. in part.)

Hab.—So. States (*Drummond, Ravenel*), Ill. (*Hall*), Col. (*Wolfe*), Nev. (*Watson*). (Eu.)

Bib.—Syn. Hep. p. 607, Hep. Europ. p. 170.

Delin.—Lindenberg Monog. Ric. t. XXII.

17. **R. lutescens** Schwein. Thallus light green, orbicular, 2.5—3.8 cm. in diameter; divisions 6—8, linear, twice or three times forking, narrowly channeled above, obcordate and convex-thickened at the apex, with delicate, whitish, obliquely ovate, appressed scales, and destitute of rootlets above the middle underneath; reproductive organs entirely unknown.

Hab.—In exsiccated pools and ditches; Can. to Fla., Mo. and Tex.; common.

Bib.—Spec. Flor. Amer. Sept. p. 26, Mem. Amer. Acad. n. ser. iv, p. 176, Pro. Phil. Acad. 1869, p. 234.

Delin.—Mem. Amer. Acad. n. ser. iv, t. IV; Lindenberg Monog. Ric. t. XXVI.

18. **R. tenuis** Aust. Thallus thin, olive or yellowish green, shining; divisions 2 or 4, expanded, roundish-obovate, plane, 4—8 mm. long, the margins sinuate; beneath green, narrowly carinate by a slender costa, with a few delicate rootlets; fruit in the nerve; capsule extremely delicate, closely adhering to the substance of the thallus, crowned with a minute oblong style; spores round or short oval with a conspicuous depression in one end when dry, bursting through neither surface of the thallus.

Hab.—Wet broken ground in open woods. Closter, N. J. (*Austin*), near Lawrence, N. J. (*James*), Mo. (*Hall*).

Bib.—Pro. Phil. Acad. 1869, p. 233.

Exsic.—Hep. Bor.-Amer. No. 150.

** *Thalli dimorphous or polymorphous, pseudo-aquatic.*

19. **R. fluitans** L. Thallus thin, green, orbicular, radiately expanding, 2.5—5 cm. in diameter, floating, often forming extensive patches; divisions often much imbricated or somewhat entangled, narrowly linear, usually 1—1.5 mm. wide, repeatedly forking, fibrous-nerved in parallel lines, plane above, convex and eradiculose beneath, cavernous only toward the apex; apices slightly dilated, very obtuse or subtruncate, emarginate; fruit present only in some terrestial forms, very prominent below, at length rupturing beneath the thallus. (*Ricciella fluitans* Al. Braun.) —— *Forma* LATA has a broader thallus and a minute patch of fuscous purple, triangular scales at the extremities of the divisions underneath; sterile. —— *Forma* NODOSA (*R. nodosa* Bouch.) has the thallus here and there tuberously thickened; sterile. —— *Forma* CANALICULATA (*R. canaliculata* Hoffm.) is small, pale, terrestrial from drying up of waters on which it floated; divisions narrower and thicker, more or less channeled above, radiculose beneath; rarely fertile. —— *Forma* TERRESTRIS is darker green with divisions shorter and slightly depressed-canaliculate above; usually fertile. Passes through the above forms to

Var. **Sullivanti** Aust. Thallus orbicular, radiately much divided, cellular-succulent, shining, yellowish green, 0.6—1.7 cm. in diameter; divisions twice or three times forked, linear, about 1 mm. wide, straight, canaliculate above, carinate thick-

ened beneath, cavernous the entire length; margins thin, undulate-crisped and crenulate; carina copiously radiculose, tumid from the abundant fruit; capsules single, crowned by a long, obliquely-ascending, funnel-mouthed, exserted style; spores obscurely angular, reticulate and margined, submuricate (*R. Sullivanti* Aust).

Hab.—Ponds, ditches and wet places; common. (Eu.) The variety in damp ground or cultivated fields.
Bib.—Syn. Hep. p. 610, Hep. Europ. p. 171.
Delin.—Lindenberg Monog. Ric. t. XXIV.
Exsic.—Hep. Bor.-Amer. No. 147, 148, 149.

20. **R. natans** L. Thallus large, purple, very narrowly channeled above, the epidermis with numerous uniform air-cavities beneath it, rooting toward the base and at length furnished with large dark purple scales at the apex underneath; divisions 0.8—1.2 cm. long, obcordate or obcuneate, broadly emarginate at the thin apex; rootlets very long, usually smooth within; infloresecence beneath the groove in one or two rows; ostioles very short, purple; spores angular, black, strongly papillose. (*Ricciocarpus natans Corda.*)

Hab.—Vegetating in summer in muddy bottoms of exsiccated pools, etc., sometimes terrestrial. Canada to Gulf of Mexico. (Eu.)
Bib.—Syn. Hep. p. 606, Hep. Europ. 172, Pro. Phil. Acad. 1869, p. 233-4.
Delin.—Lindenberg Monog. Ric. t. XXXI, XXXII.
Exsic.—Hep. Bor.-Amer. No. 144, 145.

II. THALLOCARPUS Lindb.

Thallus loosely spongy-reticulate, irregularly subpalmately lobed, thin, ecostate, the epidermis not distinct. Rootlets not papillose within, very long, interwoven. Fruit immersed in the substance of the thallus. Calyptra crowned with the black persistent style. Spores firmly united in fours into a sort of coccus, finely reticulate and papillose. Name from Gr. *thallos*, a shoot, and *karpos*, fruit.

1. **T. Curtisii** Aust. Thallus with somewhat imbricated, flabelliform divisions which are palmately or incisely-lobed; lobes crenate and obtuse, extremely thin and hyaline; spores

fuscous-black, strongly muricate. (*Riccia Curtisii*, in Herb. James, *Cryptocarpus Curtisii* Aust.)

Hab.—Moist ground, N. C. (*Curtis*), S. C. (*Ravenel*).

Bib.—Pro. Phil. Acad. 1869, p. 231, Torrey Bull. VI, p. 21, 305.

III. SPHÆROCARPUS Mich.

Fruit aggregated in the thallus. Involucre sessile, obtusely conic or pyriform, perforated at the apex, continuous at the thallus, 1-fruited. Calyptra crowned with a deciduous style, closely investing the globose capsule. Capsule indehiscent. Spores globose, muriculate, remaining united in a coccus. Antheridia in folliculose bodies on the surface of separate thalli. Thallus ecostate, epidermis not distinct. Name from Gr. *sphairos*, a sphere, and *karpos*, fruit.

1. **S. Micheli** Bell. Thallus orbicular, 0.6—1.3 cm. in diameter, lobed, the lobes entirely concealed by the aggregated, inflated involucres; involucres about 1.5 mm. long, three to four times the length of the capsule, obtuse or subtruncate; coccus 0.102—0.127 mm. in diameter, indistinctly lobed. (*S. terrestris* Mich., *Targionia sphærocarpa* Dicks.)

Var. **Californicus** Aust. Thallus substipitate, deeply lobed; lobes often leaf-like; involucre oblong or subcylindric, slightly acuminate. (*S. Californicus*, Aust., *S. Berterii*, Aust. not of Mont.)

Hab.—Cultivated fields, S. C. (Eu.) The variety in Cal.

Bib.—Syn. Hep. p. 595, Hep. Europ. p. 164.

Delin.—Lindenberg Monog. Ric. t. XXXVI.

Exsic.—Hep. Bor.-Amer. No. 138.

2. **S. Texanus** Aust. Thallus smaller, its lobes very slightly acuminate; involucre less obtuse at apex; spores about one-half as large as in *S. Micheli*, coccus 0.063 mm. in diameter.

Hab.—Texas (*Wright, 1849.*)

Bib.—Torrey Bull. VI, p. 158.

3. **S. Donnellii** Aust. Male thallus narrow, amber brown, with stipe-like base; lobes spike-like; female thallus with substipitate base and leaf-like lobes; coccus deeply lobed 0.145—0.170 mm. in diameter; spores strongly tuberculate, 0.078—0.101 mm. in diameter.

Hab.—Gardens, etc. Fla (*J. Donnell Smith*).

Bib.—Torrey Bull. VI, p. 157.

ORDER II. MARCHANTIACEÆ CORDA.

Terrestrial (rarely amphibious), usually perennial plants with thallose vegetation. Thallus dichotomously, subpalmately or radiately branched, usually continuous or proliferous from the apex of the midrib or from its side underneath, more or less thickened in the middle, furnished beneath with numerous long rootlets, and usually colored and imbricating scales (root-like hairs in *Dumortiera*). Epidermis more or less distinct, usually porose. Capsules globose, rarely obovate or oval, attached to the underside of disk-like receptacles which are elevated on peduncles (in a bivalved receptacle underneath the apex of the thallus in *Targionia*), opening variously or indehiscent. Elaters usually present, mixed with the spores.

ARTIFICIAL SYNOPSIS OF GENERA

A. Fruit aggregated underneath large, peduncled receptacles . . . . . B
A. Fruit sessile under the apex of the thallus which is small with conspicuous pores. XIII. TARGIONIA.

B. Inner involucre present C
B. Inner involucre wanting . . . . . E

C. Inner involucre conspicuous, split into 8-16 pendent, linear divisions. X. FIMBRIARIA.
C. Inner involucre 4-5 lobed . . . . . D

D. Carpocephalum 7-9 rayed. I. MARCHANTIA.
D. Carpocephalum hemispheric, 1-4 lobed, with as many rib-like rays. II. PREISSIA.

E. Outer involucre present . . . . . F
E. Outer involucre wanting; thallus obcordate, barely costate, eporose. VI. CRYPTOMITRIUM.

F. Carpocephalum entire at margin or nearly so . . . . . G
F. Carpocephalum lobed, cleft or divided . . . . . H

G { Thallus copiously reticulate and porose. IX. CONOCEPHALUS.
Thallus obscurely reticulated. V. DUVALIA.

H { Lobes of carpocephalum scarcely distinguishable from the involucres....I
Lobes of carpocephalum clearly apparent....K

I { Thallus distinctly areolate and porose, squamigerous. XII. LUNULARIA.
Thallus rigid, indistinctly porose. XI. AITONIA.

K { Andrœcium peduncled; thallus large, thin, with a slight costa. VIII. DUMORTIERA.
Andrœcium (so far as known) sessile....L

L { Thallus very indistinctly porose. VII. ASTERELLA.
Thallus clearly porose....M

M { Carpocephalum 3-4 lobed, hemispheric or conoidal. IV. GRIMALDIA.
Carpocephalum 2-4 divided to base. III. SAUTERIA.

I. MARCHANTIA L.

Plant diœcious. Carpocephalum peduncled, radiate or lobed. Peduncles areolate, arising from a sinus in the apex of the expanded forking thallus. Outer involucres alternate with the rays, 2-valved, lacerate, membranous, enclosing several 1-fruited, 4-5-parted involucres. Calyptra persistent, fissured at the apex. Capsule globular, exserted, pendulous, dehiscent by several revolute segments or teeth. Spores smooth. Elaters long, slender, attenuate at each end, bispiral. Andrœcium peduncled, peltate, radiate or lobed. Thallus large, areolate, porose, with a broad diffused midrib, densely rooting. Gemmæ lenticular, borne in a cup-shaped receptacle on the back of the thallus. Named for *Nicholas Marchant*, a French botanist, d. 1678.

1. **M polymorpha** L. Thallus usually 5—12.5 cm. long, 1.3—3.8 cm. wide, canaliculate, and with numerous small pores above, plicate-venulose; carpocephalum deeply divided into usually 9 terete rays; peduncles 2.5—7.5 cm. high, stout, pilose; involucres many-fruited; androecium on a naked peduncle 2.5 cm. high or less, crenately or often palmately 2-8-lobed, the lobes flat.

Hab.—Ditches and wet places; common. (Eu.)
Bib.—Syn. Hep. p. 522, 789; Hep. Europ. p. 150.
Delin.—Sulliv. Mosses U. S. t. VI.
Exsic.—Hep. Bor.-Amer. No. 127.

2. **M. disjuncta** Sulliv. Thallus 2.5—5 cm. long, 0.6—1.3 cm. wide, innovating from the apex; carpocephalum $\frac{3}{4}$ circular, radiately 3-7-lobed, the lobes flat, cuneate, crenulate on the outer margin; peduncles 2.5 cm. high; andrœcium large, on a stout peduncle 2—4 mm. high, digitately parted, the divisions elongate-oblong or linear-oblong, subentire.

Hab.—Springy places, banks of Alabama R. near Clairborne (*Sullivant*).
Bib.—Mem. Amer. Acad. n. ser. III, p. 63.
Delin.—Mem. Amer. Acad. n. ser. III, t. III.
Exsic.—Musc. Alleghan. No. 286; Hep. Bor.-Amer. No. 128.

II. PREISSIA Nees.

Carpocephalum hemispheric, 1-4-lobed, with as many riblike rays alternating with and shorter than the lobes, fibrous-barbulate underneath. Outer involucres as many as the rays, attached to the under side of the lobes, 1-3-fruited, opening beneath and outwardly by an irregular line. Inner involucre obconic-campanulate, angular, unequally 4-5-lobed. Calyptra persistent, rupturing obliquely at the apex. Capsule large, distinctly pedicelled, dehiscing by 4-8 revolute segments. Spores grossly tuberculate. Elaters short, bispiral. Inflorescence diœcious or monœcious. Thallus obcordate, sparingly forked, increasing by joints from the apex; pores conspicuous. Gemmæ wanting. Named for *L. Preiss*, a German botanist.

1. **P. hemisphærica** Cogn. Monœcious or sometimes diœcious; thallus 2.5—5 cm. long, 0.6—1.3 cm. wide, with conspicuous white pores above and dark purple, imbricated scales beneath; carpocephalum somewhat angled by the prominent keel-like rays; peduncle 1—2.5 cm. high, slightly hairy or squamulose; capsules conspicuous, dark purple; andrœcium peduncled, peltate, repand-lobed at the margin, the peduncle 1—2.5 cm. high. (*Marchantia hemisphærica* L., *M. commutata* Lindenb., *Preissia commutata* Nees.)

Hab.—On slate and limestone rocks in moist ravines, N. J. westward to Col. and northward to Hudson's Bay. (Eu.)

Bib.—Syn. Hep. p. 539; Hep. Europ. p. 152.

Delin.—Sulliv. Mosses U. S. t. VI.

Exsic.—Hep. Bor.-Amer. No. 129.

III. SAUTERIA Nees.

Carpocephalum peduncled, 2-4 parted, the fruit-bearing lobes separate to the base, the intermediate rays obsolete or tooth-like. Peduncle pale, naked at the base, continuous with the thallus. Outer involucres as many as the lobes forming a declined tube, more or less separate, dehiscing with a wide slit and disclosing a 2-5 parted pileus, 1-fruited. Inner involucre wanting. Calyptra persistent, pyriform-campanulate, bursting irregularly, equalling or slightly exceeding the involucre. Capsule globose, 4-6-valved, pedicelled. Elaters formed at the base of the capsule, bi-quadrispiral, deciduous. Thallus subsimple or continuous at the apex, without median costa, papillose and porose above, squamous below. Gemmæ wanting.

1. **S. limbata** Aust. Thallus obovate-oblong, sub-dichotomous, concave, reticulate-papillose and light-green above, much thickened, dark-purple and squamous beneath, with a broad, membranous, dark-purple, subplicate, undulate-crenate, incurved margin; scales closely imbricate, purple, the lower ones large, oblique, 2-horned, nodose-dentate and placed near the margin of the thallus; the upper still larger, lanceolate and extending beyond the apex of the thallus as an inflexed fringe, at length whitish; carpocephalum 1-3-fruited, shortly but

densely paleaceous underneath; peduncle about 2.5 cm. high, pale, naked, sulcate.

Hab.—Under wet rocks, Cal. (*Bolander*).
Bib.—Pro. Phil. Acad. 1869, p. 229.

IV. GRIMALDIA Raddi.

Carpocephalum peduncled, 3-4-lobed, decurrent, hemispheric or conoidal, papillose and porose at the apex. Calyptra rupturing by lobes. Capsule circumscissile in the middle. Andrœcium on the same or a different thallus, housed disciform, oval, obovate or obcordate, immersed in the apex of the thallus, papillose. Thallus thick, deeply canaliculate, dichotomous, innovating from the apex, articulated, closely areolated and porose-scabrous above, the thick keel covered with imbricated scales often extending beyond the margin as a fringe. Epidermis very thick. Gemmæ wanting. Named for *D. Grimaldi*, an Italian botanist.

1. **G. barbifrons** Bisch. Thallus linear-obcuneate, 0.6—1.3 cm. long, 3—4 mm. wide, 2-lobed at the apex, pale-green with distinct white pores above, strongly involute when dry, the scales often extending far beyond the margin and becoming whitish; peduncle profusely paleaceous at the base and apex; monœcious, the andrœcium obcordate. (*G. fragrans* Corda., includes *G. sessilis* Sulliv.)

Hab.—Thin soil on rocks. Ia. (*Horton*), Ill. (*Hall*), Tex. (*Wright*), N. J. (*Austin*), N. Y. (*Miss Waterbury*), Conn. (*Eaton*). (Eu.)
Bib.—Syn. Hep. p. 550; Hep. Europ. p. 156.
Delin.—Sulliv. Mosses U. S. t. VII.
Exsic.—Hep. Bor.-Amer. No. 133.

2. **G. Californica** Gottsche, MS. is an unpublished species from California.

V. DUVALIA Nees.

Carpocephalum peduncled, hemispheric, entire, cavernose-papillose above, concave and not decurrent beneath. Outer involucre intramarginal. Inner involucre wanting. Capsule deoperculating above the middle. Andrœcium suborbicular.

immersed in the apex of the lobes at the sinus, covered by a closer and more sharply papillose epidermis. Thallus weak, moderately thickened in the middle, bifid and sinuate-continuous from the apex, obscurely areolate above, concolorous or often purple, obscurely squamulose along the costa underneath, the scales minute and evanescent. Gemmæ wanting.

1. **D. rupestris** Nees. Thallus 0.6—1.3 cm. long, 2—6 mm. wide, the margins membranous; carpocephalum small, semiglobose, 1-4-fruited; peduncle about 2.5 cm. high, sparingly involucrate at the base, barbulate at the apex; involucres 1-fruited, short, thin crenulate; spores tuberculate; elaters bispiral. (*Grimaldia rupestris* Lindenb.)

Hab.—Calcareous or slaty rocks, Ontario (*Macoun*), O. (*Miss Biddlecome*), Central and Northern N. Y. (Eu.)

Bib.—Syn. Hep. p. 553, Hep. Europ. p. 156.

Exsic.—Hep. Bor.-Amer. No. 134.

VI. CRYPTOMITRIUM Aust. nov. gen.

Carpocephalum on a peduncle arising from a marginal sinus, large, peltate, slightly convex and papillose above, with costa-like rays extending about half way toward the plane, naked, crenate margin and tuberously thickened from the end, flattish and naked beneath. Both involucres wanting. Calyptra very obscure or ephemeral. Capsules 4-7, large, pale, obliquely depressed, globose, immersed between the rays and closely adherent to the walls of the cavity, or at length partly emergent through an irregular longitudinal slit, dehiscent near the apex by a very small, irregular, oblique, brownish operculum, the orifice becoming very large and shortly lacerate. Spores very small, coarsely rugose and reticulate. Elaters very long and slender, attenuate at the ends, tortuous, bispiral. Thallus obcordate, cespitose-imbricate, thin and barely costate, eporose above, sparingly rooted, usually purplish and very imperfectly squamulose beneath. Gemmæ wanting. Name from Gr. *kruptos*, concealed, and *mitrion*, a turban.

1. **C. tenerum** Aust. Thallus 0.6—1.3 cm. long, striate or venulose-lacunose, crenulate on the margin, very slightly thickened in the middle, the cuticle beneath breaking up into

deciduous, more or less scale-like fragments; peduncles 2.5 cm. high, rather delicately cellular, pale above, purplish below, naked. (*Marchantia tenera* Hook., *Duvalia tenera* Gottsche. *D. pedunculata* Mont.)

Hab.—Cal. (*Parry, Bigelow, Bolander, Torrey*).
Bib.—Syn. Hep. p. 554.

VII. ASTERELLA Beauv.

Carpocephalum conic-hemispheric, becoming flattened, 1-6 (usually 4)-lobed, barbulate-palæaceous beneath. Outer involucres 1-fruited, coherent with the lobes, 2-valved. Inner involucre wanting. Calyptra minute, lacerate, persistent at the base of the capsule. Capsule greenish, globose, nearly sessile, rupturing at the apex by irregular narrow teeth, or by a fragmentary operculum. Spores tuberculate. Elaters moderately long, mostly bispiral. Inflorescence monœcious; andrœcium sessile, lunate-disciform. Thallus rigid, very indistinctly porose, the midrib broad, strong and distinct. Name the diminutive of Lat. *astrum*, a star, alluding to the mature carpocephalum.

1. **A hemisphærica** Beauv. Thallus forking and increasing by joints from the extremities, rather pale-green above, purple beneath; carpocephalum papillose on the summit, diminishing greatly by age; peduncle bearded at its base and apex, at first 2—2.5 cm. long, increasing often to 5—7.5 cm. after maturity of fruit. (*Reboulia hemisphærica* Raddi, *R. microcephala* Tayl.)

Hab.—Shaded banks chiefly along streams; common. (Eu.)
Bib.—Syn. Hep. p. 548, 790; Hep. Europ. p. 154.
Delin.—Sulliv. Mosses U. S. t. VI.
Exsic.—Hep. Bor.-Amer. No. 132.

VII. DUMORTIERA Nees.

Carpocephalum convex above, 2-8-lobed. Involucres 1-fruited, opposite and connate with the lower surface of the lobes, horizontal, opening by a vertical slit at the outer extremity. Inner involucre wanting. Calyptra rupturing at the apex.

Capsule oblong-globose, dehiscing by 4-6 irregular valves, distinctly pedicelled. Spores minute, muriculate. Elaters parietal,* very long, straight, attenuate at both ends, bi-trispiral. Andrœcium short peduncled, paleaceous underneath the margin (in the young state ciliate). Thallus large, thin, soft, with a slight costa, dichotomous, continuous or articulate at the apex, with or without pores, usually with hair-like rootlets scattered over the entire under surface. Gemmæ wanting. Named for *B. C. Dumortier*, a Beigian botanist, born 1797.

1. **D. hirsuta** Nees. Diœcious; thallus 5—15 cm. long, 1.3—2 cm. wide, thin, deep-green, becoming blackish, plane and entire on the margins, exareolate and naked, or sometimes with a delicate, coarsely reticulated, closely appressed, cobweb-like pubescence above, hirsute and esquamulose beneath; carpocephalum many-fruited, convex, its margins like those of the involucres, closely setulose, the upper surface sparingly so; peduncle rather long, chaffy at the apex, slightly involucrate at the base, otherwise naked; capsule wall composed of very long thick cells containing broad rings or bands; andrœcium on a short peduncle, setulose over the entire upper surface; fruit rare. (*Marchantia hirsuta* Swz.)

Hab.—Faces of moist calcareous rocks, S. C. (*Ravenel*), Easton, Pa. (*Porter*), La. (*Featherman*).

Bib.—Syn. Hep. p. 543, 790.

Delin.—Sulliv. Mosses U. S. t. VI.

Exsic.—Hep. Bor.-Amer. No. 130.

IX. CONOCEPHALUS Neck.

Carpocephalum conic-mitriform, membranous. Involucres 5-8, tubular, 1-fruited, suspended from the apex of the peduncle, coherent with the interior surface of the carpocephalum. Inner involucre wanting. Calyptra persistent, campanulate, 2-4-lobed at the apex. Capsule oblong-pyriform, dehiscing by 5-8 revolute segments, pedicelled. Spores muriculate. Elaters short, thick, bispiral. Andrœcium disciform or oval, sessile near the apex of the thallus. Thallus dichotomous, copiously

* Adhering to the inner face of the capsule wall.

reticulated, with a narrow distinct costa. Gemmæ wanting. Name from Gr. *konos*, a cone, and *kephale*, head, alluding to the conic carpocephalum.

1. **C. conicus** Dumort. Thallus 5-15 cm. long, 1-2 cm. wide: carpocephalum conic, striate, crenate at the margin. (*Marchantia conica* L., *Conocephalus vulgaris* Bisch, *Fegatella conica* Corda.)

Hab.—Shady banks of rivulets; common. (Eu.)
Bib.—Syn. Hep. p. 546; Hep. Europ. p. 155.
Delin.—Sulliv. Mosses U. S. t. VI.
Exsic.—Hep. Bor.-Amer. No. 131.

X. FIMBRIARIA Nees.

Carpocephalum pedunculate from the apex of the thallus or its innovations, conic or hemispheric, concave beneath and expanded at the margin into usually 4 large, pendent, campanulate, 1-fruited involucres. Inner involucre oblong-oval or subconic, protruding half its length beyond the involucre, with the projecting portion cleft into 8-16 fringe-like segments which are often more or less coherent at the apex. Calyptra with a long style, fugacious. Capsule scarcely pedicelled, globose, irregularly circumscissile near the middle. Spores angular, slightly reticulate, apparently margined. Elaters rather short, uni-quadrispiral. Antheridia immersed in the thallus, without receptacle. Thallus thickened in the middle, with a keeled costa, which in some species throws out lateral innovations, usually conspicuously porose above, and with dark purple scales beneath. Gemmæ wanting. Name from Lat. *fimbriæ*, a fringe.

* *Peduncles more or less pilose; divisions of inner involucre coherent at their apices.*

† *Inner involucre 8-cleft.*

1. **F. elegans** Spreng. Thallus 0.6—2.1 cm. long, 2—4 mm. wide, producing innovations from the costa underneath and also from the apex, linear-oblong, the innovations obcordate, emarginate or bilobed at the apex, glaucous-green and moderately porose above, abruptly carinate and usually dark purple

beneath, the margin undulate-crisped and more or less tinged with purple, the costa usually densely villous-radiculose and sparingly furnished with narrow and inconspicuous scales; peduncles arising from both the apex of the thallus and the innovations, 0.8—2. cm. high, usually dark-purple below, sparingly pilose or paleaceous except at the apex or often rather copiously so throughout, the base not involucrate; carpocephalum subhemispheric, strongly tuberculate above, barbulate-paleaceous beneath, papillose-crenulate on the margin; inner involucre ovate, tawny; a variable species.

Hab.—On calcareous rocks, Tex. (*Wright*), Cuba. (Eu.)
Bib.—Syn. Hep. p. 564; Hep. Europ. p. 159.
Exsic.—Hep. Bor.-Amer. No. 136c.

2. **F. fragrans** Nees. Thallus linear-cuneate, thick crenulate, convex beneath, the scales extending to the margin or the uppermost exceeding it, barbed at the ends; inner involucre ovate. (*Marchantia fragrans* Schleich.)

Hab.—N. Mex. (*Fendler*). (Eu.)
Bib.—Syn. Hep. p. 558; Hep. Europ. p. 158.
Exsic.—Hep. Bor.-Amer. No. 136b.

†† Inner involucre 10-cleft; plant small and delicate.

3. **F. Bolanderi** Aust. Thallus narrowly-linear, 1.3—2.1 cm. long, 2—3 mm. wide, with very numerous minute innovations especially near the base, solid, rigid, light-green, depressed caniculate, indistinctly porous above, carinate-thickened and dark-purple beneath, the margins membranous, whitish and pellucid or often purple, bifid or 2-horned at the apex, somewhat dentate; peduncle slender 2.5—3.8 cm. high, slightly pilose at base, arising from the apex of the innovations; carpocephalum small, 4-fruited, subconic when moist, flattish and subcruciate when dry; inner involucre subglobose, white; spores papillose-reticulate with a pellucid margin; elaters tri-quadrispiral.

Hab.—On the ground in fields. San Rafael, Cal. (*Bolander*).
Bib.—Pro. Phil. Acad. 1869, p. 230.
Exsic.—Hep. Bor.-Amer No. 136d.

††† Inner involucre 12-16 cleft; peduncles stout, purple.

4. **F. Californica** Hampe. Thallus obcordate, 0.6—1. cm. wide, undulate-lobed, abruptly carinate, the scales beneath not reaching beyond the broad brownish-purple margin; peduncle stout, rigid, pale purple, sparingly pilose; carpocephalum subhemispheric, convex-umbonate, mostly 4-lobed, paleaceous beneath; inner involucre large. (Near *F. Lindenbergiana* Corda.)

Hab.—Cal. (*Bolander, Bigelow*).
Exsic.—Hep. Bor.-Amer. No. 135.

5. **F. violacea** Aust. Thallus rigid and much thickened, sublinear, concave canaliculate, closely areolate and pale green above, imperfectly squamulose and densely rooting beneath, distinctly punctate, dark purple, innovating from the midrib beneath; margins strongly involute when dry; scales dark purple, short and narrow, slightly exceeding the margin at the apex of the thallus; peduncles dark purple, sparingly pilose, arising from the apex of the innovations which are often scarcely 2 mm. long; carpocephalum large, mostly 3-fruited, not lobed, obtusely conic, nearly smooth and distinctly porose above, barbulate-chaffy beneath; inner involucre pyriform-ovate, the segments violet purple.

Hab.—Cal. (*Bolander*).
Bib.—Torrey Bull. III, p. 17.

** *Peduncles naked; divisions of inner involucre not coherent at least when dry.*

6. **F. tenella** Nees. Thallus orbicular and composed of several elongated, obcuneate divisions, or by abortion of a single division; divisions emarginate at the apex, 1.3—2.1 cm. long, 3—4 mm. wide, grizzly-green and conspicuously porose above, purple on the margins, abruptly keeled and purple underneath; peduncle naked, 2.5—7.5 cm. high, not involucrate at the base, usually dark purple; carpocephalum obtusely conic, 3-4-fruited, naked beneath; inner involucre white, 8-cleft. (*F. nigripes* Bisch., *F. mollis* Tayl.)

Hab.—On damp ground in sandy fields, rarely in rock crevices. N. Eng. to Mo., Ga. and Tex.
Bib.—Syn. Hep. p. 562.
Delin.—Sulliv. Mosses U. S. t. VI.
Exsic.—Hep. Bor.-Amer. No. 136.

7. **F. pilosa** Tayl. Thallus bifurcate or dichotomous, 2–6 mm. long, subspatulate or narrowly obcordate, obtuse, emarginate, the margins thin and hyaline, repand-undulate, divergently striate and distinctly porose above, squamous beneath: scales large, fuscous purple, paler toward the apex, not reaching the margin; carpocephalum rather small, hemispheric, 3-4-fruited, umbonate and minutely verruculose in the center when dry, somewhat barbulate beneath at its juncture with the peduncle: peduncle 2.5—3.8 cm. high, tapering from a stout base, naked, fuscous brown, shining: inner involucre rather large, 8-12-cleft: spores large, rugose-cristate: elaters short somewhat obtuse, bispiral: andrœcium in a distinct lobe next the fertile one, circular, immersed. (*Marchantia pilosa* Wahl., *M. gracilis* Web. f., *F. gracilis* Lindb.)

Hab.—Br. Col. (*Macoun*), Greenland (*Vahl*). (Eu.)
Bib.—Syn. Hep. p. 557; Hep. Europ. p. 157.

F. Palmeri Aust. (Torrey Bulletin VI, 47), found by Dr. Palmer in Gaudalupe Island off Lower California, may occur in So. California.

XI. AITONIA Forst.

Carpocephalum deeply 1-4-lobed, the lobes small, ascending, discrete, their apices merging into ample, vertically bivalved involucres. Peduncle emerging from a pit in the back of the thallus, involucrate. Involucres subcompressed, ovoid, erect, 1-fruited, opposite and concealing the lobes of the receptacle, vertically or horizontally dehiscing, 2-valved. Inner involucre wanting. Calyptra lacerate and persistent. Capsule globose, nearly sessile, somewhat horizontal, rupturing at the apex by an irregular vertical line. Spores enveloped in a transparent, rugose membrane, many angled, smoothish. Elaters of medium length, bi-quadrispiral. Andrœcium disciform, muricate-papillose, immersed in the apex or the middle of the thallus. Thallus rigid, thick, indistinctly porose, continuous or innovating from the apex, or proliferous from the costa underneath. Named for William Aiton, a Scottish botanist, 1731–93.

1. **A. Wrightii** (Sulliv.). Thallus 1—2 cm. long, 3—4 mm. wide, continuous from the apex, glaucous above with dark purple scales, the margins crenulate, ascending, convolute; involucres usually 3; peduncle scarcely 2 mm. high, paleaceous at the base and apex. (*Plagiochasma Wrightii* Sulliv.)

Hab.—Under overhanging rocks along streams. Tex. (*Wright*).

Delin.—Sulliv. Mosses U. S. t. VI.

2. **A. erythrosperma** (Sulliv.) Thallus expanded, obovate, 0.6—1 cm. wide, pale green, rugulose, fuscous margined, radiculose and squamous beneath; scales whitish, setaceous-incised, extending beyond the margin toward the apex; peduncle 1—1.7 cm. high, naked at the base, paleaceous at the apex; spores orange-red, tuberculate; elaters quadrispiral. (*Plagiochasma erythrosperma* Sulliv.)

Hab.—Rocky Mts. (*E. Hall*).

XII. LUNULARIA Mich.

Carpocephalum cruciately divided into 1-6 (usually 4) horizontal segments or involucres, which are tubular, vertically bilabiate and 1-fruited. Inner involucre wanting. Calyptra included, persistent, rupturing at the apex. Capsule exserted on a long pedicel, 4-8-valved, the valves spreading, subtortuous. Spores minute, nearly smooth. Elaters short, very slender, bispiral, deciduous or a few remaining attached to the apex of the valves. Peduncle very hairy, 2.5—3.8 cm. high, involucrate with numerous membranous scales at the base. Andrœcium oblong, sessile in the sinus at the apex of the thallus. Thallus oblong, with rounded lobes, distinctly areolate and porose, squamigerous. Scales imbricate, sublunulate, their apex abruptly contracted into a roundish cochleariform lobe. Gemmæ in crescent-shaped disks on the back of the thallus. Name from Lat. *lunula*, a little moon, alluding to the gemmæ-bearing receptacles.

1. **L. cruciata** Dumort. Thallus 2.5—5 cm. long, furcately divided, innovating from the apex, with a somewhat diffused costa. (*L. vulgaris* Mich., *Marchantia cruciata* L.)

The only species; introduced into greenhouses; always sterile. (Eu.)

Bib.—Syn. Hep. p. 511; Hep. Europ. p. 147.

Exsic.—Hep. Bor.-Amer. No. 126.

XIII. TARGIONIA Mich.

Carpocephalum wanting, the involucre being sessile beneath the apex of the thallus, bivalved, 1-fruited. Inner involucre wanting. Calyptra thin, persistent. Style deciduous. Capsule short pedicelled. Spores globose, tuberculate. Elaters bi-trispiral. Andrœcium lateral, disciform, papillose, rising on a separate innovation from the ventral costa. Thallus furcate and continuous from the apex, conspicuously porose, squamulose beneath.

1. **T. hypophylla** L. Thallus 0.4—1.3 cm. long, obcuneate-linear or obovate, rigid, costate, involute when dry, with more or less conspicuous whitish pores above, dark purple beneath: scales densely imbricate, 2-horned or caudate, the upper ones extending to the margin of the thallus. (*T. Michelii* Corda.)

Hab.—Cal. (*Bolander*).
Bib.—Syn. Hep. p. 574; Hep. Europ. p. 162.
Exsic.—Hep. Bor.-Amer. No. 137.

ORDER III. ANTHOCEROTACEÆ Lindb.

Terrestrial, annual plants with thallose vegetation. Capsule dorsal, pod-like, mostly erect and bivalved, usually with stomata in its outer wall, tapering into a pedicel or often sessile with a bulbous base. Columella filiform. Involucre tubular, the inner wanting. Calyptra rupturing early near the base, carried up on the apex of the capsule, crowned with a subsessile stigma. Spores flattish, more or less convexo-prismatic, papillose or smooth. Elaters with or without fibres. Texture flaccid, more or less vesiculose; epidermis and pores wanting.

I. ANTHOCEROS L.

Monœcious or sometimes diœcious. Involucre tubular. Capsule linear or cylindric-oblong, bivalved. Spores papillose or smooth, colored. Elaters simple or branched, often geniculate, more or less heteromorphous, the fibres wanting or indis-

tinct. Thallus dark green or blackish, usually depressed, variously lobed and divided. Texture lax, vesiculose, with large chlorophyll grains, frequently glandularly thickened at the apex or in streaks along the middle so as to appear nerved. Name from *anthos*, flower, and *keras*, horn, from the appearance of the fructification.

* *Spores yellow; elaters yellow or with a yellowish tinge.*

† *Thallus usually smooth.*

1. **A. laevis** L. Thallus smooth, nearly plane above; involucre 2—4 mm. high, trumpet-shaped when dry, the mouth repand-toothed, often thickened, rarely scarious; capsule pale brown or yellowish, 2.5—3.8 cm. high, the valves often twisted when dry; spores rather small, nearly smooth, flattish, angular; elaters rather short, geniculate, somewhat articulated, yellowish.

Var. **major** Aust. Larger in all its parts except the spores and elaters. (*A. Carolinianus* Michx., *A. laciniatus* Schwein.)

Hab.—Can. to the Gulf of Mexico and Cal.; the var. southward and in Cal. (Eu.)

Bib.—Syn. Hep. p. 586; Hep. Europ. p. 160; Torrey Bull. VI, 25.

Delin.—Sulliv. Mosses U. S. t. VI.

Exsic.—Hep. Bor.-Amer. No. 123, 123b.

2. **A. Donnellii** Aust. Diœcious; thallus plane, rather narrow, smooth, very distinctly wide-nerved, deeply laciniate, somewhate crenate, copiously tuberous below; involucre large, funnel form, the mouth incised; capsule yellow; spores and elaters as in No. 1.

Hab.—Banks of Caloosahatchee R., Southwest Fla. (*Austin*); rare.

Bib.—Torrey Bull. VI, 304.

3. **A. Mohrii** Aust. Thallus thick, opaque, subcristate, lacunose, densely radiculose beneath, nerveless, tuber-bearing within; involucre short, thickened, the mouth truncate, indistinctly many crenate, often scarious-margined; capsule thick, rigid, yellowish-brown or blackish, variously curved and twisted, rather long pedicelled; spores ochreous, numerous, minutely papillose, opaque or somewhat pellucid; elaters various, some long and some short.

Hab.—Port Royal, S. C. (*Austin*), Mobile, Ala. (*Mohr*).

Bib.—Torrey Bull. VI, 304.

†† *Thallus more or less glandular.*

4. **A cæspiticius** DeNot. Thallus dissected to the base, the divisions 4—8.5 mm. long, narrow, variously lobed, expanded at the apex, dark green, more or less glandular; involucre broad, scarcely 2 mm. high, broadly sulcate and obtusely 2-angled on the back, minutely punctate, the apex subtruncate, repand-tridentate, the mouth narrowly scarious; capsule thick 1—1.5 cm. long, sessile, sulcate or angled, the apex obtuse and subtruncate; columella thickish, fibrillose. (*A. tuberosus* Tayl.)

Hab.—Tex.? Cal. (Eu.)

Bib.—Syn. Hep. p. 588; Hep. Europ. p. 161; Torrey Bull. VI, 25.

5. **A. Hallii** Aust. Thallus 1.3—2.5 cm. long, 1—2 mm. wide, cæspitose, often erect, linear or elongate-flabelliform, the apex entire or slightly lobed, most usually glandulose-thickened; involucre terminal, pellucid, pale green, 2—3 mm. long, the apex truncate; capsule about 6 mm. long, short pedicelled, sulcate, very narrow, the valves thick; spores smooth.

Hab.—On the ground and on rocks; Silverton and Salem, Ore. (*Hall*), Marine Co., Cal. (*Bolander*).

Bib.—Torrey Bull. VI, 26.

6. **A. Oreganus** Aust. Thallus thin, glandular-thickened in places, involucre very short, abruptly constricted above the middle, inflated below, minutely and closely punctate, the mouth subtruncate, slightly repand-lobate; capsule sessile, bulbous at base, somewhat thickened, about 1.3 cm. long, the valves splitting to the mouth of the involucre, coherent at the apex; spores small, indistinctly granulose.

Hab.—Ore. (*Hall*).

Bib.—Torrey Bull. VI, 26.

7. **A. sulcatus** Aust. Thallus 4—6 mm. long, deep green, apparently hollow, cæspitose, erect, attenuate at base, flabelliform, the margin variously lobed and repand; involucre obovate-quadrate, about 1 mm. high, somewhat roughened; capsule 4—5 mm. high, narrow, erect, or somewhat curved, sulcate, almost sessile, compressed-glandular; spores rather large; elaters short.

Hab.—On moist earth; Salem, Ore. (*Hall*).

Bib.—Torrey Bull. VI, 27.

** *Spores black; elaters fuscous.*

8. **A. punctatus** L. Thallus small, depressed, or often caespitose and somewhat erect, lax, more or less glandular, often falsely nerved; involucre rather short, oblong-linear, slightly repand, sometimes scarious at the mouth; capsule 2.5 cm. high, black; spores rather small, strongly muriculate, sharply angled; elaters rather short and broad, flattish, geniculate, variously contorted, somewhat articulated. Of several forms varying more or less from the type. *Var. scariosus* Aust. has the thallus lamellate, the involucre lamellate and broadly scarious at the mouth (*A. scariosus* Aust.)– *Var. Ohionensis* Aust. has the thallus distinctly nerved, the apex of the lobes much thickened and solid.—*Var. Eatoni* Aust. has the thallus caespitose and erect, crowded, the involucre narrower, more or less lamellate, parallel to the surface of the thallus and more or less connate with it.

Hab.—Can. to Fla. and Mo. Var. *scariosus* in S. C. (*Ravenel*); var. *Ohionensis* in O. (*Lesquereux*); var. *Eatoni* in Fla. (*Eaton*, *Smith*), Cuba, (*Wright*). (Eu.)

Bib.—Syn. Hep. p. 583; Hep. Europ. p. 160; Torrey Bull. VI, 27, 304.

Exsic.—Hep. Bor.-Amer. No. 122.

9. **A. fusiformis** Aust. Differs from No. 8 in its larger size, its more dissected thallus, its much longer subfusiform involucre (4—8.5 mm. long); capsule black, 2.5—5 cm. long, solid; spores minutely papillose; elaters brownish, longer, narrower, more opaque. Probably a form of the last.

Hab.—Cal. (*Bolander*), Ore. (*Hall*), Observation Inlet (*Scouler*).

Bib.—Torrey Bull. VI, 28.

10. **A. stomatifer** Aust. Differs from No. 8 in the more solid thallus with glandulose-cristate margin; involucre longer, narrower, rising from the margin of the thallus; capsule longer, more slender, well provided with stomata, the valves much twisted in drying; spores a little larger, more papillose, deep black.

Hab.—Ore. (*Hall*).

Bib.—Torrey Bull. VI, 28.

11. **A. Ravenelii** Aust. Thallus small, thick, broadly flabelliform, pale when young, black when older, the laciniae short, repand or lobed; involucre short, 1—1.5 mm. high, the

mouth somewhat truncate; capsule 0.6—2 cm. high, very thick, provided with stomata, the pedicel very short; spores large, plano-convex, distinctly papillose; elaters small, somewhat triangular prismatic. (*A. Lescurii et A. Joorii* Aust. are mature forms of the plant as originally described.)

Hab.—On moist earth; S. C. (*Ravenel*), Fla (*Austin*), La. (*Joor*).
Bib.—Torrey Bull. VI, 28, 29, 305.

12. **A. Olneyi** Aust. Thallus subprostrate or erect, somewhat oblong-flabelliform, variously lobed or crenate, substriate-venose, with large, black, tuberculate granules beneath its surface; involucre cylindric, about 2 mm. high, slightly striate, impunctate, the apex truncate, the mouth crenate, repand or dentate; capsule 0.6—2 cm. high, erect; spores large, plano-convex, opaque, minutely papillose-granular; elaters strongly compressed, articulated.

Hab.—Fla. (*Chapman*).
Bib.—Torrey Bull. VI, 29.

II. NOTOTHYLAS Sulliv.

Monœcious, the fructification dorsal, scattered. Involucre sessile, continuous with the thallus, closed at first, at length splitting by chinks above. Capsule very short, included in the involucre, oblong-spheroidal, compressed or ovate-cylindric, pedicelled, the pedicel arising from a thickened bulb, the suture breaking in small pieces. Columella linear. Spores in fours, subglobose, smoothish. Antheridia immersed in the thallus, elliptic-globose. Thallus orbicular, laciniate, tender, papillose-reticulate, the margin undulate, crisped, radiculose beneath. Name from Gr. *notos*, the back, and *thulas*, a bag, from the shape and position of the involucre.

1. **N. orbicularis** Sulliv. Thallus 0.6—1.6 cm. wide; capsules more or less curved, 2—4 mm. high, erect or decumbent, wholly included in the involucre or slightly exserted, marked with a suture on each side, the texture thin and rather loose; elaters minute, pale, nearly or quite as long as broad; antheridia immersed in cavities which have their sides slightly

elevated. (*Targionia orbicularis* Schwein., *Carpobolus orbicularis* Schwein., *Carpolipum orbiculare* Nees., *Anthoceros orbicularis* Aust. Includes *N. valvata* Sulliv.)

Hab.—Can. to Gulf of Mexico.

Bib.—Syn. Hep. p. 591, 792; Mem. Amer. Acad. n. ser. III, p. 65; Torrey Bull. VI, 27.

Delin.—Mem. Amer. Acad. n. ser. III, t. IV; Sulliv. Mosses of U. S. t. VI.

Exsic.—Musc. Alleghan. No. 289; Hep. Bor.-Amer. No. 124.

2. **N. melanospora** Sulliv. Thallus small, depressed or sometimes caespitose, the texture lax; capsule much as in No. 1; spores dark fuscous, smooth, larger by half than those of No. 1. (*Anthoceros melanosporus* Aust.)

Hab.—Moist ground, O. (*Sulliv*).

Bib.—Mem. Amer. Acad. n. ser. III, p. 65; Torrey Bull. VI, 29.

Exsic.—Musc. Alleghan. No. 290; Hep. Bor.-Amer. No. 125.

ORDER IV. JUNGERMANIACEÆ Dumort.

Terrestrial or rarely somewhat aquatic, chiefly perennial plants with either thallose or foliaceous vegetation. Capsule borne on an elongate, cellular pedicel, dividing lengthwise into four valves or quadridentate. Elaters present, uni-quadrispiral. Thallus with or without a midrib. (Genera I—VI.) Leaves when distinct, 2-ranked, often with a third row of smaller ones (*amphigastria*) on the under side, incubous (Genera VII—XI, XIII—XVIII) or succubous (Genera XII, XIX—XXXII).

The following artificial synopsis, tho imperfect, may assist in determining species:

ARTIFICIAL SYNOPSIS OF GENERA.*

A
- Vegetation thallose .... B
- Vegetation pseudo-foliaceous; the lobes of the thallus leaf-like, succubous; inner involucre large, campanulate, with a large, more or less lobed and undulate mouth. VI. Fossombronia.
- Vegetation foliaceous.............................. F

* See also Appendix C for another synoptic table.

B	Midrib wanting or not apparent.................... C
	Midrib clearly apparent.......................... D
C	Sporogonium dorsal; elaters bispiral, free. II. PELLIA.
	Sporogonium borne on under side of thallus near the margin; elaters unispiral, adherent to the apex of the valves. I. ANEURA.
D	Inner involucre tubular, at first terminal, at length dorsal; thallus sinuate or lobed. IV. STEETZIA.
	Inner involucre wanting or early vanishing......... E
E	Outer involucre wanting; fructification apical; thallus simple or bifid. III. BLASIA.
	Outer involucre monophyllous, ventricose; sporogonium arising from lower surface of midrib; thallus furcate. V. METZGERIA.
F	Leaves incubous: i.e. the apex lying on the base of the next one above .... G
	Leaves succubous: i.e. the apex lying under the base of the next one above .... O
G	Leaves bilobed or with a small ventral lobe at base.. H
	Leaves without ventral lobe at base, mostly 3-5-toothed, lobed or parted............................. L
H	Amphigastria present* I
	Amphigastria wanting; lower lobe usually convex underneath. XI. RADULA.
I	Amphigastria entire or 2-toothed .... K
	Amphigastria 4-5-lobed; lobes of leaves divided. XIII. BLEPHAROZIA.

* Amphigastria are obsolete or wanting in three species of *Lejeunia*.

K
- Lower lobe of leaf auriculate; inner involucre with a mucronate mouth. VII. FRULLANIA.
- Lower lobe of leaf concave underneath; inner involucre with a small denticulate mouth. X. MADOTHECA.
- Inner involucre terete or angular, variously winged, cristate or ciliate at the angles, the mouth 3-4-lobed or dentate. VIII. LEJEUNIA.
- Inner involucre somewhat depressed, plane and bilabiate, the mouth trilobed or tridentate. IX. PHRAGMICOMA.

L
- Inner involucre wanting.........................M
- Inner involucre present.........................N

M
- Leaves entire or 2-toothed; outer involucre pendent. XVIII. CALYPOGEIA.
- Leaves palmately divided; fructification in a fork, not pendent. XV. TRICHOCOLEA.

N
- Leaves 2-cleft to the middle; the divisions lanceolate. XIV. SENDTNERA.
- Leaves and amphigastria 3-5-parted half way to the base or more, the lobes usually lanceolate. XVII. LEPIDOZIA.
- Leaves bi-tridentate at the apex. XVI. BAZZANIA.

O*
- Amphigastria present.........................P
- Amphigastria wanting.........................U

P
- Amphigastria entire or nearly so.........................Q
- Amphigastria 2-4-cleft, parted or divided.........................S

Q
- Involucral leaves numerous; inner involucre at first triquetrous often becoming plicate, the mouth denticulate, ciliate or laciniate. XXVI. CEPHALOZIA.
- Involucral leaves few.........................R

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* The forms with succubous leaves included in the genera beyond this point of the synopsis cannot be satisfactorily arranged in a synoptic table; the characters of the genera are poorly defined and they contain very diverse forms, some of which are described from imperfect and incomplete data, which makes their reference to genera uncertain.

R
- Inner involucre distant from the outer, fusiform, the mouth 3-5-fid, the laciniæ unequal; involucral leaves smaller than those of the stem. XXV. HARPANTHUS.
- Inner involucre elongate, cylindric, longer than the calyptra, the mouth compressed-bilabiate; involucral leaves connate at base. XXVII. COLEOCHILA.
- Inner involucre elongate fusiform, rising from the lower side of the stem, fleshy, solid, rooting at the base, the mouth compressed, 2-3-cleft; involucral leaves 3, minutely scale-like. XXII. PLEURANTHE.
- Involucral leaves small, incised; inner involucre arising from the ventral side of stem, terete, trigonal at the apex; the mouth denticulate. XXIV. ODONTOSCHISMA.
- Not included in the above. XXVIII. JUNGERMANIA.*

S
- Involucre saccate, fleshy, attached by one side of its mouth to the stem, pendent. XIX. GEOCALYX.
- Involucral leaves few, large; inner involucre tubular below, acutely triquetrous above, dilated and three-lobed at the mouth, the lobes toothed-crested; leaves decurrent on the dorsal side of the stem. XXI. LOPHOCOLEA.
- Involucral leaves more numerous.................T

T
- Involucral leaves smaller than those of the stem and differing from them; inner involucre usually short, deeply 2-3-cleft; leaves usually deeply 2-cleft. XX. CHILOSCYPHUS.
- Involucral leaves imbricate, jointed-ciliate; inner involucre terete, glabrous, contracted and ciliate at the mouth; leaves 3-4-parted, the divisions bristle-form. XII. BLEPHAROSTOMA.

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* The genus *Jungermania*, altho its original limits have been much reduced, still contains a heterogeneous lot of species that cannot be properly classified until, 1st. The limits of genera become more clearly defined, and, 2nd. The sporogony phase of all of our species becomes known.

U. Leaves complicate-bilobed, the dorsal lobe usually smaller; inner involucre compressed parallel to the plane of the stem, the apex usually decurved, the mouth truncate, entire or ciliate. XXIX. SCAPANIA.

NOTE.—Some forms of *Jungermania* without amphigastria have the leaves complicate-concave and may be sought here, especially Nos. 20, 21, 22 and 28. See foot note under R in this table.

Leaves bilobed or bifid at apex, not complicate V

Leaves entire or merely dentate at apex X

V. Involucre many leaved .... W

Involucre few leaved; some forms of XXVIII JUNGERMANIA.

W. Involucral leaves imbricate; inner involucre wanting; leaves closely imbricate. XXXII. CESIA.

Involucral leaves united nearly to the top into an oblong tube; inner involucre 6-toothed, connate with the outer. XXXI. NARDIA.

Involucral leaves free; inner involucre present; some forms of XXVI. CEPHALOZIA.

X. Involucral leaves larger than those of the stem; inner involucre compressed at right angles to the plane of the stem, the mouth truncate, entire or ciliate-toothed; leaves often turned to one side. XXX. PLAGIOCHILA.

Involucral leaves similar to those of the stem; inner involucre retrorsely subarcuate or at length cylindric; the mouth contracted, ciliate; the cilia articulate, connivent in a short cone; leaves entire. XXIII. LIOCHLÆNA.

Not included in the above are some species of the ubiquitous XXVIII JUNGERMANIA.

I. ANEURA Dumort.

Diœcious. Sporogonium arising from the under side of the thallus near the margin. Outer involucre cup-shaped, very short and lacerate or wanting. Inner involucre wanting. Calyptra ascending, nearly cylindric, fleshy. Capsule oval or oblong, 4-valved. Elaters unispiral, adherent to the apex of the valves. Antheridia immersed in the upper surface of receptacles proceeding from the margin of the thallus. Thallus fleshy, destitute of a midrib. (Riccardia B. Gr., Lindberg.)

* *Calyptra tuberculate.*

1. **A. multifida** Dumort. Thallus brownish-green, prostrate, pinnately divided, the primary portion biconvex, somewhat rigid; branches horizontal, the secondary pectinately pinnate with narrow linear divisions; fructification from the primary portion or from lateral branches; involucre top-shaped, fleshy. (*Jungermania multifida* L.)

Var. **major** Nees. Primary portion and branches thick, the branches interruptedly bipinnate; all the divisions short, obtuse. (*Jungermania bipinnata* Schwein.)

Hab.—On decaying wood and moss in swamps. N. J. (*Austin*), Alleghany Mts. (Eu.) The var. growing over mosses on rocks.

Bib.—Syn. Hep. p. 496, 788; Hep. Europ. p. 141; Schweinitz Spec. Flo. Amer. Sept. p. 20.

Delin.—Brit. Jung t. 45 ff 3 et 6; Ekart t. VII f. 50.

Exsic.—Hep. Bor.-Amer. No 116, 116 b.

2. **A. palmata** Nees. Thallus palmately divided, the primary portion depressed-plane, procumbent; branches ascending, 4—6 mm. high, pinnatifid-palmate, the divisions linear, obtuse or truncate; fructification lateral; involucre lacerate. (*Jungermania palmata* Hedw.)

Hab.—Rotten logs, etc. Eastern U. S. (Eu.)

Bib.—Syn. Hep. p. 498, 788; Hep. Europ. p. 143.

Delin.—Ekart t. XIII f. 115.

Exsic.—Hep. Bor.-Amer. No. 114.

** *Calyptra merely papillose at apex.*

3. **A. sessilis** Spreng. Thallus decumbent, irregularly lobed, 2.5—5 cm. long, 0.6—1 cm. wide; involucre wanting; pedicel 2—2.5 cm. long, sometimes folded upon itself and remaining within the calyptra, thus making the capsule appear sessile; sterile receptacles elongate.

Hab.—Wooded swamps. Eastern U. S.

Bib.—Syn. Hep. p. 495, 788; Mem. Amer. Acad. n. ser. III, p. 62.

Delin.—Mem. Amer. Acad. n, ser. III, t. V; Sulliv. Mosses, U. S. t. VII.

Exsic.—Hep. Bor.-Amer. No. 113.

*** *Calyptra smoothish.*

4. **A. pinguis** Dumort. Thallus decumbent or ascending, subsimple, somewhat linear; involucre short, lacerate; calyptra cylindric; sterile receptacles 2-lobed, the lobes obtuse. (*Jungermania pinguis* L.)

Hab.—Wet banks, So. States, O., Penn., N. J. (Eu.)

Bib.—Syn. Hep. p. 493-4; Hep. Europ. p. 143.

Delin.—Brit. Jung. t. 46; Ekart t. VII, f. 51.

Exsic.—Hep. Bor.-Amer. No. 112, 112 b.

5. **A. pinnatifida** Nees. Thallus pinnately divided or subsimple, flat or subcanaliculate; branches horizontal, the broader pinnatifid or dentate, obtuse.

Hab.—On dripping rocks, Hokokus, N. J. (*Austin*), near New Haven, Conn. (*Eaton*). (Eu.)

Bib.—Syn. Hep. p. 495, 788; Hep. Europ. p. 142.

Delin.—Ekart t. XIII f. 109.

Exsic.—Hep. Bor.-Amer. No. 115.

II. PELLIA Raddi.

Monœcious. Involucre arising from the upper side of the thallus near the apex, cup-shaped, short, the margin lacerate-dentate. Inner involucre wanting. Calyptra oval, membranous, longer or shorter than the involucre. Capsule globose. Elaters long, free, bispiral. Antheridia globose, immersed in the broad indeterminate costa of the thallus. Named for *Sig. A. L. Pelli*, an Italian botanist.

1. **P. epiphylla** Nees. Thallus rather membranous, sparingly divided, the divisions oblong or somewhat wedge-shaped, repand-lobed; calyptra distinctly tuberculate, exserted. (*Jungermania epiphylla* L.)

Hab.—On ground in springy places, ditches, etc. (Eu.)
Bib.—Syn. Hep. p. 488; Hep. Europ. p. 145; Torrey Bull. VI, 30.
Delin.—Brit. Jung. t. 47; Ekart t. VII f. 52; Sulliv. Mosses U. S. t. VII.
Exsic.—Hep. Bor.-Amer. No. 110.

2. **P. calycina** Nees. Thallus dichotomous, proliferous, the early divisions linear-oblong, the margins ascending, remotely sinuate; later divisions linear-palmatifid, coarsely nerved, the areolæ large, hexagonal; involucre ciliate-fringed or lacerate at the mouth; calyptra smooth, included. (*Jungermania calycina* Tayl.)

Hab.—Wet limestone and slate rocks. (Eu.)
Bib.—Syn. Hep. p. 490; Hep. Europ. p. 145; Torrey Bull. VI, 30.
Delin.—Brit. Jung. t. 47 f. 18.

III. BLASIA Mich.

Sporogonium in an oval cavity in the midrib of the thallus. Outer involucre wanting. Inner involucre wanting or a fusiform utricle vanishing early. Calyptra obovate. Capsule oval-globose, bursting through the thallus near its apex. Antheridia immersed in the thallus, covered with dentate scales. Gemmæ globose, issuing by a slender ascending tube from their large flask-like receptacles which are immersed in the thallus. Named for *P. D. Blasius*, a companion of Micheli.

1. **B. pusilla** L. Thallus 1.5—2.5 cm. long, 4—6 mm. wide, linear-obovate, simple or forked or stellately expanded, the margins pinnatifid-sinuous. (*Jungermania Blasia* Hook.)

Hab.—Wet banks, Eastern U. S. (Eu.)
Bib.—Syn. Hep. p. 491; Hep. Europ. p. 135.
Delin.—Brit. Jung. t. 82-84; Ekart t. XI f. 94, et t. XIII f. 114; Sulliv. Mosses U. S. t. VII.
Exsic.—Hep. Bor.-Amer. No. 111.

IV. STEETZIA Lehm.

Diœcious. Involucre at first terminal arising from the midrib of the thallus, at length dorsal, cup-shaped, short-lacerate. Inner involucre elongate, tubular, the mouth denticulate. Calyptra equaling the perianth, irregularly torn at the apex. Capsule oval, 4-valved. Elaters filiform, free, bispiral. Andrœcium dorsal on the midrib, covered with minute, fimbriated, perigonial leaves. Thallus with a distinct costa. (Dilæna Dumort.) Named for *J. Steetz*, a German botanist.

1. **S. Lyellii** Lehm. Thallus 2.5–10 cm. long, 0.6–1 cm. wide, simple or two-cleft, delicate, the margin entire, slightly crenate or obscurely serrate. (*Jungermania Lyellii* Hook., *J. sinuata* et *J. oblonga* Schwein., *Blyttia Lyellii* Endl., *Diplolæna Lyellii* Dumort., *Dilæna Lyellii* Dumort.)

Hab.—Among mosses in swamps, often aquatic; common. (Eu.)
Bib.—Syn. Hep. p. 785; Hep. Europ. p. 137.
Delin.—Brit. Jung. t. 77; Ekart t. X f. 87; Sulliv. Mosses U. S. t. VI.
Exsic.—Musc. Alleghan. No. 281; Hep. Bor.-Amer. No. 109.

V. METZGERIA Raddi.

Diœcious. Involucre arising from the lower surface of the midrib of the thallus, one leaved, scale-like, at length ventricose and two-lobed. Inner involucre wanting. Calyptra ascending, oblong-ovate, rather fleshy. Capsule ovate. Elaters unispiral, adherent to the tips of the valves. Antheridia 1-3, enclosed by a one-leaved involucre on the under side of the midrib. Gemmæ ovate, aggregated on the attenuate tips of the linear thallus. Midrib distinct. Named for *Sig. Giovanni Metzger*, an Italian botanist.

1. **M. pubescens** Raddi. Diœcious; thallus 3 cm. long, 2 mm. wide, not very elongate, alternately pinnate or somewhat decompound, the branches short, linear and of uniform width, flat, undulate on the margins, everywhere, above and below, uniformly and densely villose; the hairs beneath longer, all single, or many at the margin double or in threes, nodding, and

irregularly curved, without sucker-like branches at the apex; midribs showing scarcely any cortical layer, covered with 6-10, commonly 8 rows of very similar and uniform peripheral cells. (*Jungermania pubescens* Schrank.)

Hab.—Mountainous places eastward. (Eu.)

Bib.—Syn. Hep. p. 504; Hep. Europ. p. 140; Lindb. Monog. Metzg. n. 1.

Delin.—Brit. Jung. t. 73; Ekart t. III, f. 19; Lindb. Monog. Metzg. f. 1.

2. **M. myriopoda** Lindb. Diœcious; thallus 5 cm. long, 1 mm. wide, elongate, dichotomous, subsimple, the branches long, linear and of uniform width, convex above, the margins reflexed, not undulate; the midrib beneath densely setose-pilose, which is scarcely apparent on the foliaceous portion of the thallus; hairs rather long, straight or nodding, the marginal ones in bundles of 3-6, rarely single or double, some of them with sucker-like branching extremities; midribs covered above with two rows of enlarged cells, beneath with 3-7, commonly 4-6, rows of smaller, lax, often indistinct cells. (*Jungermania ciliifera* Schwein., *Metzgeria furcata*, Sulliv. Musc. Alleghan. No. 283.)

Hab.—On shaded rocks and trees, Alleghany Mts. (*Sullivant*), Tenn. (*Frederickson*), N. Orleans (*Drummond*).

Bib.—Lindb. Monog. Metzg. n. 6, f. 4.

Exsic.—Musc. Alleghan. No. 283, "specimen solum dextrum."

3. **M. hamata** Lindb. Diœcious; thallus 10 cm. long, 2.5 mm. wide, most frequently much elongate, dichotomous, the branches long, linear, and of uniform width, strongly convex to slightly rounded above, the margins reflexed not undulate, the midrib densely setose-pilose beneath, which never extends to the foliaceous portion of the thallus; the hair very long, divaricate and hooked-deflexed, the marginal double, scarcely ever with sucker-like branching extremities; midribs both above and below covered with two rows of enlarged, lax cells.

Hab.—Alleghany Mts. (*Sullivant*).

Bib.—Lindb. Monog. Metzg. n. 7, f. 5.

Exsic.—Musc. Alleghan. No. 283, "specimen solum sinistrum."

4. **M. conjugata** Lindb. Monœcious; thallus 3.5 cm. long, 1–2 mm. wide, commonly dichotomous, the branches short, linear, narrower in some parts, convex above, the margins more or less distinctly undulate, the midribs and margins pilose with rather long, straight, divaricate hairs; the hairs usually double and very frequently with sucker-like branches at their extremities; midribs covered above with two, below with 3-6 rows of enlarged lax cells. (*Echinogyna furcata*, Dumort., *Metzgeria furcata* Dumort. in part.)

Hab.—On shaded siliceous rocks and trunks of living trees, etc. Catskill Mts., N. Y. (*P. T. Cleve*), Cal.? (*Bolander*). (Eu.)

Bib.—Lindb. Monog. Metzg. n. 8, f. 6; Hep. Europ. p. 139 (sub. *M. furcata*).

Delin.—Brit. Jung. t. 56, f. 2; Ekart, t. I, f. 1.

Exsic.—Hep. Bor.-Amer. No. 117.

VI. FOSSOMBRONIA Raddi.

Involucral leaves 5-6, minute, subulate, coherent with the perianth almost its entire length. Inner involucre terminal or by innovation dorsal on the main stem, subcampanulate, the large mouth open, crenate-lobed. Calyptra pear-shaped, rupturing early. Capsule globose, irregularly 4-valved. Elaters short, uni-trispiral. Andrœcium naked, borne on the back of the stem. Vegetation pseudo-foliaceous, the lobes of the thallus-like stem leaf-like, succubous, somewhat quadrate, 3-5 lobed, flaccid. Named for *Sig. Car. Vittorio Fossombroni*, an Italian minister of state.

* *Leaves mostly horizontal.*

† *Plant medium size or large.*

1. **F. pusilla** Nees. Plant small; stems 1.3—2.1 cm. long, usually subsimple yet forked-divergent or subdichotomous at the apex; leaves obliquely spreading, the lower undulate-lobed, the lobes barely mucronate, the upper angular, 3-4 lobed, crisped, the lobes narrower; inner involucre obconic, dentate; crests of the spores angular, subparallel. (*Jungermania pusilla* L.)

Hab.—On damp ground, mostly in unfrequented paths. (Eu.)

Bib.—Syn. Hep. p. 467; Hep. Europ. p. 14.

Delin.—Brit. Jung. t. 69; Ekart t. V, f. 38; Sulliv. Mosses U. S. t. VII.

Exsic.—Hep. Bor.-Amer. No. 120.

2. **F. angulosa** Raddi. Stems subsimple, narrowly forked at the apex; leaves subquadrate, horizontally expanded, the upper undulate-lobed with obtuse lobes; inner involucre conic-dilated, crenate; spores coarsely reticulate.

Hab.—Brackish meadows; common; fruiting in early spring. (Eu.)

Bib.—Syn. Hep. p. 468, Hep. Europ. p. 15.

Exsic.—Hep. Bor.-Amer. No. 119.

3. **F. Cubana** Aust. Near the last but the leaves broader, spores more minutely reticulate, elaters narrower. (*F. pusilla* var. *Cubana* Gottsche, *F. Texana* Lindb.)

Hab.—Tex. and Cuba (*Wright*).

Bib.—Bot. Bulletin (now Bot. Gazette) I, 36.

†† Plant small.

4. **F. cristula** Aust. Plant minute, whitish; stems 2—4 mm. long, forked or fastigately divided; leaves quadrate or obovate-rotund, subentire, strongly crisped-undulate; capsule on a short pedicel, immersed; spores pale fuscous, more or less tuberculate; elaters delicate, one-celled, short, more or less difform, with a single narrow annular and spiral fibre.

Hab.—On moist sand in unfrequented paths near Batsto, N. J. (*Austin.*)

Bib.—Pro. Phil. Acad. 1869, p. 228.

Exsic.—Hep. Bor.-Amer. No. 121.

5. **F. longiseta** Aust. Stems suberect or depressed, 6—8 mm. long, proliferous-branching from the dorsal surface, attached to the earth by purple rootlets; leaves pale, subimbricate, subhorizontal, subquadrate, the lobes mostly obtuse, undulate-lobed or subentire, the lower few and small; involucral leaves much larger, subflabelliform, somewhat attenuate at base and confluent with the apex of the stem into a tube; inner involucre mostly large, campanulate, variously incised or subentire; capsule large, filling the calyptra, bursting irregularly; pedicel rather long (8—12 mm.), slender, the base considerably included in the apex of the stem; spores subangular, blackish, strongly muricate; elaters rather long, bispiral. (*Androcryphia longiseta* Aust.)

Hab.—Cal. (*Bolander*), Tex. (*Wright*).

Bib.—Pro. Phil. Acad. 1869, p. 228.

Exsic.—Hep. Bor.-Amer. No. 118.

** *Leaves vertical, incurved.*

6. **F. Macouni** Aust. Stems thickened, very short, leaves imbricate, strongly cristate-undulate and plicate, acutely incised-dentate; inner involucre small, cup-shaped or funnel-shaped, the margin crenate and somewhat undulate; capsule large, exserted; spores very small, somewhat opaque, minutely and closely papillose; elaters rather thick, bispiral.

Hab.—Portage la Lochs, lat. 57° Canada (*Macoun*).
Bib.—Bot. Bulletin (now Bot. Gazette) I, 36.

VII. FRULLANIA Raddi.

Diœcious. Sporogonium terminal on the branches. Involucral leaves 2 or 4, 2-lobed, not auriculate. Inner involucre oval or obovate, terete or 3-4-angled, mucronate at the apex by a tubular mouth. Calyptra pear-shaped, persistent, rupturing below the apex. Capsule globular, 4-cleft halfway down. Elaters truncate at both ends, unispiral, adherent to the valves, erect. Spores large, irregular, minutely muricate. Archegonia 2 or 4. Antheridia in the saccate base of closely imbricate, 2-lobed perigonial leaves. Leaves 2-lobed, the lower lobe usually an inflated helmet-shaped auricle. Amphigastria entire or 2-toothed, throwing out rootlets from the base. Named for *Sig. Leonardo Frullani*, an Italian minister of state.

* *Auricles galeate or cucullate-rotund.*

† *Amphigastria small, scarcely wider than the stem.*

‡ *No tooth on the margin of the involucral leaves.*

a. *Auricles much smaller than the leaves.*

1. **F. Eboracensis** Gottsche. Stems creeping, clustered-branched; leaves loosely disposed (those of the branches imbricate), round-ovate, entire; amphigastria ovate, a little wider than the stem, bifid, entire; inner involucre smooth, pyriform, slightly compressed and repand, beneath obscurely carinate and gibbous toward the apex. (*F. saxatilis* Lindenb., *F. microscypha, læviscypha et nana* Tayl.)

Hab.—Trees and rocks; common northward.
Bib.—Syn. Hep. p. 423.
Exsic.—Hep. Bor.-Amer. No. 105.

2. **F. saxicola** Aust. Stems closely creeping, numerous and widely branching; leaves orbicular, scarcely oblique, plane, the auricles approximating the stem, small, rarely larger, and then rotund-galeate; amphigastria scarcely wider than the stem, subovate, bifid: inner involucre broadly oblong, the mouth very short, bowl-shaped, papillose, beneath abruptly and broadly carinate. 1-many nerved on both sides the carina, 2-angular.

Hab.—"On inclined surface of dry trap rocks, Closter, N. J." (*Austin*), Tex. (*Wright*).

Bib.—Pro. Phil. Acad. 1869, p. 225.

Exsic.—Hep. Bor.-Amer. Nos. 104.

b. *Auricles about three-fourths the size of the leaves.*

3. **F. Oakesiana** Aust. Stems widely branching, the fertile branches short, sub-erect; leaves somewhat obliquely orbicular, loosely imbricate; sub-convex, the margins slightly repand, the auricles almost equaling the leaves, rotund, nearly contiguous to the stem; amphigastria ovate-rotund or sub-obovate, little wider than the stem, bifid, entire or subserrulate: inner involucre small, subobovate-pyriform, somewhat inflated, broadly carinate beneath, smooth or 1-7-nerved or alate on both sides; involucral leaves bilobed, entire, more or less connate, the lobes equal, obtuse, parallel.

Hab.—On bark of stunted spruce and birch trees; White Mts. (*Oakes, Austin*).

Bib.—Pro. Phil. Acad. 1869, p. 226.

Exsic.—Hep. Bor.-Amer. No. 105c.

4. **F. Sullivantii** Aust. Stems closely appressed, short branching; leaves subrotund, convex, entire, obtuse, the auricle large, galeate-rotund, equaling $\frac{3}{4}$ the width of the leaf, approximate to the stem; amphigastria obovate, obtusely bifid, subentire, scarcely wider than the stem, those toward the fructification oblong or cuneate, the lobes obtuse or the uppermost acute; inner involucre obovate, subcompressed, short-beaked, dorsally 1-2-nerved, ventrally unicarinate, the carina 2-angled or 2-winged; involucral leaves rotund, connate with the inner involucre, and one or the other with the amphigastria.

Hab.—On the bark of trees; Ga. (*Sullivant*), S. C. (*Curtiss*).

Bib.—Pro. Phil. Acad. 1869, p. 226.

‡‡ *A tooth on the margin of the involucral leaves above the middle of the lower lobe.*

5. **F. Pennsylvanica** Stephani. Diœcious; stems creeping, dichotomous-branching; leaves imbricate, plane, ovate, mucronate, more rarely obtuse, entire; cells charged with chlorophyll, smaller toward the base, much dilated at the base, more or less regularly hexagonal, thick walled; auricles naked, rising from the margin of the leaves, large, cucullate-rotund, slightly contracted beneath the hood, extending beyond the margin of the leaves; amphigastria subimbricate, plane, broadly ovate, exceeding the stem, deeply parted with a narrow obtuse sinus, the laciniæ ovate, long acuminate, connivent; male spikes on short lateral branches, elongate, with loose foliage; involucral leaves complicate, entire, the lobes ovate, acuminate, much narrowed at the base; involucral amphigastrium large, carinate-concave, deeply parted, the laciniæ ovate apiculate, entire or with one or more teeth.

Hab.—In rocky places in shade; Stony Creek, Carbon Co., Penn. (*Rau.*)
Bib.—Hedwigia, No. 10, 1883; Torrey Bull. X, 132.

6. **F. Hallii** Aust. Stems prostrate, much branched at the apex, often erect, flagelliferous, with dense squarrose amphigastria; fruit-bearing branches short, clavate, ascending; leaves small, subdistant or subimbricate, obliquely ovate-rotund, strongly convex, the apex incurved, the auricle rather large, oval-rotund, contiguous to the stem; amphigastria scarcely wider than the stem, obovate-quadrate, slightly bilobed; inner involucre broadly obovate, somewhat compressed, dorsally 2-nerved toward the apex, ventrally 4-nerved, unicarinate; involucral leaves repand-subdentate, the amphigastria ovate or rotund, entire or barely emarginate at the apex, the margins entire or obtusely dentate.

Hab.—On trees; Salem, Ore. (*E. Hall*).
Bib.—Torrey Bull. VI, p. 20.

7. **F. Bolanderi** Aust. Stems creeping, clustered branching, flagelliferous, the fruit-bearing branch erect-ascending, clavate; leaves small, imbricate, obliquely orbicular, convex, margined, the basal auricle large orbicular-galeate; amphigastria somewhat spreading, minute, orbicular or subobovate, bifid, the lobes obtuse or somewhat acute, entire, repand-

dentate or serrulate; involucral leaves somewhat appressed, deeply connate with the amphigastria: inner involucre rather large, compressed, unequally triangular, obovate-elliptic, concave or at length somewhat convex dorsally, unequally 2-4-nerved and unicarinate ventrally, slightly 2-costate toward the apex, otherwise smooth. (*F. Petalumensis* Gottsche, in Bolander's Cat.)

Hab.—On trees near the coast; Cal. (*Bolander*).
Bib.—Pro. Phil. Acad. 1869, p. 226.
Exsic.—Hep. Bor.-Amer. No. 105b.

†† *Amphigastria 2-3 times the width of the stem.*
‡ *Leaves orbicular or suborbicular.*

8. **F. squarrosa** Nees. Stems decumbent, pinnately branching, the fruit-bearing branch short, lateral; leaves subvertical, crowded, suborbicular, obtuse, entire, the auricle obovate cucullate or galeate, somewhat appressed; amphigastria cordate or rotund, sinuate-subdentate, slightly emarginate-bifid, the laciniæ acute; inner involucre oblong, prismatic-triquetrous, convex dorsally, strongly unicarinate ventrally. (*Jungermania squarrosa* Nees, *J. tuberculosa* Lehm. et Lindenb.)

Hab.—On rocks, bark of trees, etc.; N. J. to O. and common southward.
Bib.—Syn. Hep. p. 416.
Exsic.—Hep. Bor.-Amer No. 100.

9. **F. plana** Sulliv. Monœcious; stems procumbent, widely branching or subpinnate; leaves somewhat imbricate, orbicular, the auricle small, galeate, equally broad and long, contiguous to the stem; amphigastria large, three times the width of the stem, flat, rotund, slightly bifid, the sinus and laciniæ acute; lobes of the involucre oval, the margin reflexed, subrepand, the lower margin unidentate; inner involucre on a short branch, oblong-oval or subobovate, triquetrous, dorsally sulcate, ventrally acutely unicarinate; male spikes globose.

Hab.—On shaded rocks; N. Y. and N. J. (*Austin*) to Tenn. (*Sullivant*)
Bib.—Mem. Amer. Acad. n. ser. III, p. 175.
Exsic.—Hep. Bor.-Amer. No. 102.

10. **F. Wrightii** Aust. Stems short, prostrate, the fruit-bearing branch shortened; leaves imbricate, subrotund, strongly convex, obliquely decurved, unequally cordate at base, the margin entire, the auricle rotund or subobovate; amphigastria broadly obovate, emarginate-bidentate ¼ their length, the margin repand-dentate; involucral leaves united with one another or with the amphigastria, the dorsal lobe oblong, entire or subrepand, inflexed-cucullate at the apex, the ventral lobe shorter by half, ovate-lanceolate, often subfalcate.

Hab.—N. Mex. (*Wright*).
Bib.—Torrey Bull. III, p. 15.

11. **F. æolotis** Nees. Stems procumbent, irregularly branching or subpinnate; leaves semi-vertical, subsquarrose, obliquely cordate, the auricle either galeate or expanded into a canaliculate, ovate-lanceolate lobule; amphigastria ovate, entire or the upper margin angular-dentate, acutely bifid; sporogony phase unknown. (*F. riparia* Hampe MS.)

Hab.—On trees and rocks chiefly in mountainous regions.
Bib.—Syn. Hep. p. 417.
Exsic.—Hep. Bor.-Amer. No. 101.

+++ *Leaves ovate or oval.*

12. **F. Virginica** Gottsche. Stems creeping, vaguely branching; leaves ovate, entire, somewhat concave, the auricle sometimes expanded into a lanceolate lamina; amphigastria ovate-rotund, bifid, double the width of the stem; inner involucre compressed, pyriform, tuberculate, quadricarinate ventrally, bi-quadricarinate dorsally, the carinæ tuberculate.

Hab.—On bark of trees, rarely on rocks; common.
Bib.—Syn. Hep. p. 419.
Exsic.—Hep. Bor.-Amer. No. 103.

13. **F. Hutchinsiæ** Nees *var.* Stems subpinnately branching; leaves dark olive-green verging on black, ovate, acute, entire, or subrepand, the auricle ovate, not spurred as in European forms; amphigastria roundish, plane, bifid, subserrate; inner involucre oblong-obovate, plane above, carinate beneath; involucral leaves bifid, serrate. (*Jungermania Hutchinsiæ* Hook., *Jubula Hutchinsiæ* Dumort.)

Hab.—Wet rocks chiefly in mountain rivulets. (Eu.)
Bib.—Syn. Hep. p. 426, Hep. Europ. p. 26 (sub *Jubula*).
Delin.—Brit. Jung. t. 1; Ekart, t. X, f. 82.
Exsic.—Musc. Alleghan. No. 271; Hep. Bor.-Amer. No. 106.

14. **F. Nisquallensis** Sulliv. Stems procumbent, pinnately decompound; leaves closely imbricate, obliquely oval acuminate, apiculate, strongly inflexed, the auricle small ovate-galeate; amphigastria obovate-rotund, double the width of the stem, bifid, the sinus and laciniæ somewhat obtuse, the margin reflexed; lobes of the involucre linear, deflexed-falcate, cristate-ciliate at the base; inner involucre oval-obovate, subimmersed trigonal, dorsally somewhat convex, ventrally unicarinate.

Hab.—Fort Nisqually, Ore. (*U. S. Expl. Exped.*)
Bib.—Mem. Amer. Acad. n. ser. III, p. 175.

** *Auricles oblong-cylindric or clavate (or oblong-galeate in No. 16).*

† *Leaves marked with a row of moniliform cells.*

‡ *Leaves orbicular.*

15. **F. tamarisci** Nees. Stems bipinnately branching, somewhat rigid; leaves orbicular, obtuse, mucronately acute or subacuminate, decurved, entire, marked with a moniliform median line, the auricle oval or oblong, distant from the stem; amphigastria quadrate-ovate or obovate, emarginate, revolute at the margin; inner involucre oblong, sulcate dorsally, obtusely carinate ventrally; involucral leaves bifid, serrulate. (*Jungermania tamarisci* L.)

Hab.—"In America Septentrionale" (*Beyrich*). (Eu.)
Bib.—Syn. Hep. p. 438, Hep. Europ. p. 29.
Delin.—Brit. Jung. t. 6; Ekart, t. 11, f. 17.

16. **F. Grayana** Mont. Stems creeping, simply pinnate; leaves nearly orbicular, concave, decurved, marked in the middle by a moniliform line, the auricle oblong-clavate, emarginate at the lower end; amphigastria oblong, flat, 2-cleft, the sinus obtuse; inner involucre pyriform, 3-sided, obtusely carinate beneath; involucral leaves unequally 2-cleft, the dorsal segment oblong, pointed, nearly entire, the ventral subulate. (*F. Asagrayana* Mont. in Syn. Hep. p. 441!)

Var. **Californica** Aust. MS. Dark or brownish red; stems somewhat irregularly branched; leaves obliquely ovate, obtuse or acuminate-apiculate, convex, decurved, with sometimes a few firmer and deeper colored but not enlarged cells scattered or in an oblique central row; amphigastria obovate, emarginate, flat or with recurved margins toward the apex; involucral leaves often connate with the amphigastria to the sinus, the lobes entire, obtuse or acute, the lower often narrow, channeled and somewhat contorted, with one or more hairs on the margin near the base; inner involucre oblong, triquetrous, strongly keeled below, the mouth usually emarginate. (*F. Nisquallensis* Aust. Hep. Bor.-Amer. No. 108, not of Sulliv., *F. tamarisci* (?) of Bolander's Cat., *F. unciflora* var. *Californica* Gottsche MS. (?) of Bolander's Cat.)

Hab.—On rocks and on the bark of spruce and larch trees; common in the Atlantic States; the *var.* on rocks near San Francisco, Cal. (*Bolander*) and along the coast.

Bib.—Syn. Hep. p. 441 (sub *F. Asagrayana*).

Delin.—Sulliv. Mosses U. S. t. VII.

Exsic.—Musc. Alleghan. No. 266; Hep. Bor.-Amer. No. 107, 108.

‡‡ *Leaves oblong from a narrowed base.*

17. **F. fraligifolia** Tayl. Stems procumbent, subpinnate, the branches flattened, alternate, somewhat remote; leaves subimbricate, ascending, oblong-rotund from a narrowed base, recurved, entire, marked with a moniliform line, the auricle oblong-galeate; amphigastria obovate-rotund, plane, appressed, bifid at the apex, entire or angulate at the margins; inner involucre obovate-cordate, concave dorsally, unicarinate ventrally, smooth; involucral leaves subequilobed, obtusely few toothed. (*F. polysticta* Mont., *F. Sullivantiæ* Aust.)

Hab.—On trees in cedar swamp near Urbana, O. (*Sullivant*). (Eu.)

Bib.—Syn. Hep. p. 437; Hep. Europ. p. 28; Torrey Bull. III, 16; VI, 306.

†† *Texture of the leaves uniform.*

‡ *Amphigastria double the width of the stem.*

18. **F. Donnellii** Aust. Monœcious, reddish, very small; stems with long black hairs interwoven, usually pinnately or somewhat clustered branching; leaves ovate-rotund,

somewhat convex, obtuse, entire, contiguous or imbricate, the auricle somewhat enlarged, oblong-clavate or subcylindric, distant from the stem and subparallel with it or deflexed; amphigastria double the width of the stem, subobovate, bifid, the segments somewhat obtuse; inner involucre obcuneate-oblong, flattish dorsally, slightly unicarinate toward the compressed truncate apex; involucral leaves deeply incised, serrate; andrœcium minute, globose, short-peduncled.

Hab.—E. Fla. (*J. Donnell Smith*).
Bib.—Torrey Bull. VI, 301.

‡‡ *Amphigastria narrower.*

19. **F. Kunzei** Lehm. and Lindenb. Stems creeping, simply pinnate; leaves approximate, obicular, entire, the auricle oblong-cucullate, obliquely truncate, approximate to the stem; amphigastria subremote, plane, ovate, subangular at the margin, bifid, the laciniæ erect, obtuse; inner involucre broadly obovate, compressed, acutely unicarinate ventrally; involucral leaves entire. (*F. parasitica* Mont., *F. Drummondii* Tayl.)

Hab.—Bark of trees; So. States.
Bib.—Syn. Hep. p. 449.
Exsic.—Hep. Bor.-Amer. No. 105d.

20. **F. brunnea** Spreng. Stems pinnate or bipinnate; leaves dense, 2-ranked, spreading, orbicular, entire, the auricle clavate, arising from the margin of the leaf, distant from the stem with a triangular lobe interposed; amphigastria and involucral leaves acuminate, deflexed, serrate-dentate at the margin; inner involucre oblong, sulcate dorsally, unicarnate ventrally. (*F. obcordata* Lehm. and Lindenb., *F. Caroliniana* Sulliv. Musc. Alleghan. No. 270).

Hab.—Bark of trees; So. States; rare.
Bib.—Syn. Hep p. 441.
Exsic.—Musc. Alleghan. No. 270; Hep. Bor.-Amer. No. 105e.

VIII. LEJEUNIA Libert.

Inner involucre oval or oblong, terete or angular, variously winged, cristate or ciliate at the angles, the mouth 3-4-lobed or dentate. Capsule quadrifid to the middle, the valves connivent, the pedicel tuberous-geniculate when dry. Elaters per-

sistent at the apex of the valves, erect, unispiral. Leaves delicate. Amphigastria entire or bifid. Stems faciculate or irregularly branching. Entire plant of small size, some species scarcely visible to the unaided eye. Named for *A.-L.-S. Lejeune* a French botanist.

* *Amphigastria entire or barely emarginate.*

1. **L. calyculata** Tayl. Stems entangled, branched; leaves spreading-recurved, oblong, obtuse, entire, the lower lobe involute, lanceolate; amphigastria rotund; inner involucre axillary, somewhat exserted, obcordate, 4-winged, the wings entire; involucral leaves narrow, acute.

Hab.—On lichens; Laurel Mts., Pa. (*Lea in Herb. Hook.*)
Bib.—Syn. Hep. p. 752.

2. **L. cyclostipa** Tayl. Stems 1—1.5 cm. long, widely branched; leaves pale green, imbricate, spreading-recurved, oblong, obtuse, entire, the ventral lobe quadrate-ovate, involute, one-toothed; amphigastria reniform-rotund; inner involucre terminal, obcordate, compressed, plane above, ventricose-4-winged beneath, the wings ciliate with dentate cilia; involucral leaves nearly covering the inner involucre.

Hab.—Bark of trees; near Cincinnati, O. (*Sullivant*).
Bib.—Syn. Hep. p. 749.

3. **L. polyphylla** Tayl. Stems cæspitose, 6—8 mm. long, ascending; leaves olive-green, vertical, imbricate, concave, semicordate, entire, the lobe involute, lanceolate; amphigastria minute, reniform; inner involucre immersed, rotund-obovate, 5-6-angled near the apex, the angles crested, somewhat denticulate.

Hab.—Near Cincinnati, O. (*Herb. Hook.*)
Bib.—Syn. Hep. p. 751.

4. **L. auriculata** Hook. and Wils. Stems 1—1.7 cm. long; leaves dark-green, closely imbricate, acinaciform, complicate and somewhat 2-lobed at base; amphigastria obovate-rotund, emarginate; inner involucre obovate-triangular.

Hab.—Bark of trees; La.

5. **L. testudinea** Tayl. Stems 1–1.5 cm. long; leaves whitish-green, closely imbricate, patent-divergent, oblong, nearly acinaciform, obtuse, complicate-2-lobed at the base, the lobes small, lanceolate; amphigastria rotund, minute; sporogony phase unknown.

Hab.—Bark of trees, Southern O. (*Sullivant*).

6. **L. longiflora** Tayl. Stems procumbent, widely branching; leaves almost membranous, imbricate, patent, oblong, the apex rounded, entire, the lobe minute, ovate, somewhat one-toothed, involute; amphigastria rotund, plane, scarcely bidenticulate at the apex; inner involucre lateral, sessile, somewhat naked, obovate from a narrow base, 5-winged, the wings almost entire.

Hab.—On trees, Southern O. to Fla.
Bib.—Syn. Hep. p. 763.

7. **L. Mohrii** Aust. Stems 1.3—2 cm. long, somewhat simple; leaves dirty or fuscous-green, subcontiguous, obliquely ovate, obtuse, entire or slightly repand, widely spreading, somewhat decurved, the lobe small, inflated, the apex one-toothed; amphigastria small, orbicular, distant; sporogony phase unknown.

Hab.—Mobile, Ala. (*Mohr.*)
Bib.—Torrey Bull. VI, 20.

** *Amphigastria bifid.*

8. **L. serpyllifolia** Libert, *var.* **Americana** Lindb. Stems elongate, narrower than the typical form of the species, pale, pellucid, less branching, fragile; leaves more or less remote, the anterior lobe flat, opening from a basilar sac, scarcely decurved, obliquely ovate-oval, obtuse or sometimes narrower at the apex but never acute, entire or often slightly repand, the upper margin especially in drying, the basilar sac 1/4 to 1/6 as large; amphigastria somewhat appressed, 2-3 times larger than the posterior lobe, somewhat convex or plane, rotund-oval, the sinus broad and obtuse, often semilunar, the segments acute, the margins often repand or slightly unidentate outwardly at the base of the segments; inner involucre always on

a lateral branch, obovate-clavate. (*L. serpyllifolia* Sulliv. Musc. Alleghan. No. 272, *L. cavifolia* Aust. Hep. Bor.-Amer. No. 97.)

Hab.—On trees, near Charleston, S. C. (*Sullivant*), La. (*Drummond*), Catskill Mts., N. Y. (*P. T. Cleve*), Belleville, Ont. (*Macoun*).

Bib.—Lind. Hep. Hibern. p. 488.

Exsic.—Musc. Alleghan. No. 272; Hep. Bor.-Amer. No. 97.

9. **L. Austini** Lind. Stems straightish, subsimple; leaves subimbricate, oblique, obovate-rotund, erect-patent, the margin sub-repand, the areolation rather small diminishing toward the margin, the lobe somewhat hooded, one-toothed; amphigastria 2-3 times the width of the stem, bifid with a narrow sinus, the laciniæ semi-ovate, somewhat acute; sporogony phase unknown. (*L. Sullivantiæ* Aust. which name is preoccupied as *L. Sullivanti* Gottsche is described, 1863, *Mex. Lev.* p. 196.)

Hab.—Roots of trees and on the ground; So. States (*Sullivant*), La. (*Featherman*).

Bib.—Torrey Bull. III, 15.

Exsic.—Hep. Bor.-Amer. No. 96.

10. **L. cucullata** Nees. Stems filiform, rather pinnately branching, flaccid; leaves oblong-ovate, distant, the lower margin inflexed-hooded; amphigastria distant, oval, much smaller than the leaves; inner involucre terminal on short branches, obovate, rather compressed, obtusely keeled beneath, convex above and bicarinate toward the apex; plant minute, light green. (*L. lucens* Tayl.)

Hab.—On moist rocks, Alleghany Mts. (*Sullivant*).

Bib.—Syn. Hep. p. 389, 767.

Exsic.—Musc. Alleghan. No. 274; Hep. Bor.-Amer. No. 98.

11. **L. Caroliniana** Aust. Stems 2—4 mm. long, rather flaccid; leaves somewhat fuscous, rotund, convex, squarrose-patent, subvertical, rather dense, the apex strongly decurved, the lobe small, subinflated; amphigastria rotund; inner involucre pyriform, subcompressed, 5-angled, the angles naked; male spikes large, terminal and lateral.

Hab.—With *Frullania Kunzei* from Mobile, Ala. (*Sullivant*).

Bib.—Bot. Bulletin (now Bot. Gazette), I, 36.

12. **L. læte-fusca** Aust. Stems creeping, 1—1.7 cm. long; leaves fuscous more or less imbricate, very broadly falcate-ovate, patent, slightly convex, obtuse, with 2—3 much enlarged cells in the centre next the basal row, the lobe minute, subovate: amphigastria small, orbicular, the laciniæ erect, somewhat acute: sporogony phase unknown.

Hab.—So. States? (*Sullivant*).
Bib.—Bot. Bulletin (now Bot. Gazette) I, 36.

13. **L. Ravenelii** Aust. Stems short, flexuous, convex above: leaves yellowish, imbricate, obdeltoid-orbicular, strongly convex, the lobe minute, subinflated: amphigastria minute, rotund, bilobed, the lobes obtuse; areolation of leaves large, opaque: sporogony phase unknown.

Hab.—Bark of trees, S. C. (*Ravenel*).
Bib.—Bot. Bulletin (now Bot. Gazette) I, 35.

*** *Amphigastria obsolete or wanting.*

14. **L. minutissima** Dumort. Stems capillary, flexuous, sparingly branched: leaves small, approximate, vertical, subrotund, imperfectly 2-lobed, the lower lobe an indistinct fold: amphigastria obsolete: inner involucre terminal on a rather long branch, broadly obovate, compressed, 5-angled, the mouth obtuse, papillose. (*L. ulicina* Tayl., *Jungermania minutissima* Sm.)

Hab.—Roots of trees, Ala. (Eu.)
Bib.—Syn. Hep. p. 387, 767; Hep. Europ. p. 19.
Delin.—Brit. Jung. t. 52.

15. **L. echinata** Tayl. MS. Stems loosely branching, minute, the whole plant scarcely visible to the unaided eye: leaves ovate, acuminate, cellular-echinate and denticulate, falcate-decurved, sinuate-complicate at the base: amphigastria obsolete: inner involucre on a very short lateral branch, pyriform-clavate, acutely 5-angular, the margin echinate-muricate; involucral leaves bifid, the laciniæ entire. (*L. calcarea* Libert, *Jungermania hamatifolia* var. *echinata* Hook.)

Hab.—Rocks and roots of trees; rather common. (Eu.)
Bib.—Syn. Hep. p. 344 (sub. *L. calcarea*;) Hep. Europ. p. 19.
Delin.—Brit. Jung. t. 51.
Exsic.—Musc. Alleghan. No. 275; Hep. Bor.-Amer. No. 99.

16. **L. Jooriana** Aust. Stems minute, creeping, sparingly branched, with lax foliage; leaves pale green, ovate, obtuse, somewhat plane, scarcely papillose, the lobe moderate, inflated, one-toothed; amphigastria wanting; inner involucre minute, subovate, not compressed, the apex slightly 5-angled, otherwise smooth.

Hab.—On reeds, La. (*Dr. Joor*).
Bib.—Torrey Bull. VI, 20.

L. biseriata Aust. is a doubtful species founded on few broken stems without fruit that were mixed with other species of this genus collected in 1845 by Sullivant near Augusta, Ga. There is too much uncertainty regarding this plant to refer it definitely. See Proceedings Phila. Acad. 1869, p. 225, also Botanical Gazette, II, 142.

IX. PHRAGMICOMA Dumort.

Sporogonium on a very short lateral branch. Inner involucre somewhat depressed-plane and bilabiate, the mouth trilobed or tridentate. Capsule quadrivalved a little beyond the middle, membranous, pale, the valves erect-spreading. Elaters persistent at the apex of the valves, erect, unispiral. Leaves inflexed to the base beneath. Amphigastria entire. Name from Gr. *phragma*, partition, and *koma*, hair, from the position of the elaters.

1. **P. clypeata** Sulliv. Stems 1.5—2 cm. long, procumbent, somewhat pinnately branched; leaves whitish-green, with the upper lobe round-ovate and deflexed, the lower oblong, quadrate; amphigastria orbicular, approximate; inner involucre lateral, sessile, obovate, obtusely carinate dorsally, the margin subcompressed. (*Jungermania clypeata* Schwein., *Lejeunia Dorotheæ* Lehm.)

Hab.—On rocks and trees; common southward and westward.
Bib.—Syn. Hep. p. 332 (sub *Lejeunia*).
Exsic.—Musc. Alleghan. No. 271; Hep. Bor.-Amer. No. 95.

2. **P. xanthocarpa** Lehm. and Lindenb. Stems 6—8 mm. long, creeping, subpinnately branching; leaves imbricate, ovate-subcultrate, obtuse, entire, the ventral margin straightish, the lobule convolute, ovate, the apex emarginate-truncate; amphigastria contiguous, reniform-subrotund, entire; inner involucre lateral, subsessile, obovate, emarginate, ventrally carinate, the carina 2-winged at the apex. (*Lejeunia catenulata* Nees, *Jungermania transversalis* Schwein.)

Hab.—On trees in the So. States (*Sullivant, Ravenel*).
Bib.—Syn. Hep. p. 323 (sub *Lejeunia*).
Exsic.—Hep. Bor.-Amer. No. 95b.

X. MADOTHECA Dumort.

Diœcious. Sporogonium lateral, nearly sessile. Inner involucre ovate, biconvex, the mouth bilabiate, incised or entire. Involucral leaves 2 or 4, 2-lobed. Calyptra globose, persistent, rupturing below the apex. Capsule globose, on a peduncle little exceeding the inner involucre, membranous, pale. Elaters free, attenuate at both ends, bispiral. Spores rather large, somewhat angular. Antheridia in the saccate bases of closely imbricate, 2-lobed perigonial leaves. Leaves deeply and unequally bilobed. Amphigastria large, decurrent. Name from Gr. *mados*, bald, and *theka*, capsule.

* *Amphigastria entire or nearly so.*
† *Stems commonly simply pinnate.*

1. **M. rivularis** Nees. Stems somewhat pinnate or trifid; leaves entire, closely imbricate, the lobes ovate; upper lobe convex, obtuse, decurved; lower lobe much smaller, separated nearly to the base, revolute from the middle backward; amphigastria somewhat scattered, subquadrate, rounded and reflexed at the apex; involucral leaves entire, the lobes acute, the upper ovate, the lower smaller, ovate-oblong; inner involucre bilabiate.

Hab.—On shaded rocks, near Yellow Springs, O. (*Sullivant*), Cal. (*Bolander*), N. Mex. (*Fendler*). (Eu.)
Bib.—Syn. Hep. p. 278, Hep. Europ. p. 24.
Exsic.—Hep. Bor.-Amer. No. 91b, 91c.

2. **M. thuja** Dumort. Stems creeping, sparingly branched, simply pinnate; branches short; leaves fuscous-green, closely imbricate; upper lobe strongly incurved, obtuse with the apex mucronulate or 2-4-denticulate; lower lobe oblong, somewhat acute, repand and somewhat denticulate; amphigastria broadly ovate, reflexed-spreading, subentire. (*Jungermania thuja* Dicks.)

Hab.—Ill. (*Wolf*). (Eu.)
Bib.—Hep. Europ. p. 24.

3. **M. Sullivanti** Aust. Stems mostly simply pinnate, the apex strongly decurved in drying; leaves somewhat erect, the ventral margin close, strongly involute toward the apex; cells large punctate-stelliform; inner involucre broadly carinate beneath, the carina biangular; otherwise near *M. involuta* Hampe.

Hab.—Alleghany Mts. (*Sullivant*).
Bib.—Torrey Bull. III, 15.
Exsic.—Hep. Bor.-Amer. No. 94.

†† *Stems somewhat bi-tripinnate.*

‡ *Lower lobe of leaves narrow, ovate-lanceolate.*

4. **M. involuta** Hampe. Stems irregularly pinnately decompound; leaves closely imbricate, subrotund, deflexed, repand or entire, the ventral margin slightly involute, the base decurrent, the lobe narrow; amphigastria approximate, quadrate-ligulate, entire.

Hab.—Banks of rivers, So. States (*Lesquereux, Beyrich*).
Bib.—Syn. Hep. p. 282.
Exsic.—Hep. Bor.-Amer. No. 93.

‡‡ *Lower lobe of leaves broader.*

5. **M. platyphylla** Dumort. Stems irregularly bipinnate; upper lobe of leaf roundish-ovate, the basal margin more or less undulate; the inferior lobes smaller, obliquely oval or subrotund, the margins deflexed; amphigastria round-obovate with reflexed margins, subentire; involucral leaves denticulate or entire; mouth of inner involucre nearly entire. (*Jungermania platyphylla* L., *Lejeunia platyphplla* Corda.) A variety is *Jungermania platyphylloidea* Schwein., (*Madotheca platyphylloidea* Dumort.), (*Austin*).

Hab.—On rocks and trees; common eastward. (Eu.)
Bib.—Syn. Hep. p. 278; Hep. Europ. p. 23.
Delin.—Brit. Jung. t. 40; Ekart, t. III, f. 24; Sulliv. Mosses U. S. t. VIII.
Exsic.—Hep. Bor.-Amer. No. 89, 90.

6. **M. navicularis** Nees. Stems subbipinnate, somewhat rigid, most of the branches recurved at the apex, some obtuse, others attenuate; upper lobe of leaves somewhat smooth, suborbicular, obtuse, the posterior margin undulate-crisped at the base and beyond; inferior lobe entire, obliquely cordate-oval, obtuse, deflexed, boat-shaped; amphigastria subrotund, obtuse, the margins reflexed, entire or undulate at the base; mouth of the inner involucre subentire. (*M. Californica* Hampe., *Jungermania navicularis* Lehm.)

Hab.—On rocks, Cal. (*Bolander*). (Eu.)
Bib.—Syn. Hep. p. 277 (ex parte); Hep. Europ. p. 24.
Exsic.—Hep. Bor.-Amer. No. 91.

7. **M. porella** Nees. Stems 5—10 cm. long, bi-tripinnate, the branches forked, divergent; leaves somewhat distant, the upper lobe oblong-ovate, obtuse; lower lobe much smaller, appressed to the stem, oblong, flat; amphigastria quadrate, entire; involucral leaves entire, the lobes ovate; inner involucre bilabiate, the lips subcrenate. (*M. Cordæana* Dumort., *Jungermania porella* Dicks., *Porella pinnata* Schwægr.) A variety is *Jungermania distans* Schwein. (*Austin*).

Hab.—On rocks and trees subject to inundation, common. (Eu.); the variety in the So. States.
Bib.—Syn. Hep. p. 281; Hep. Europ. p. 25.
Exsic.—Hep. Bor.-Amer. No. 92, 92b.

8. **M. Wataugensis** Sulliv. Similar to the last but smaller and more delicate, with fascicles of rootlets springing from the base of the amphigastria; leaves light yellowish brown, the upper lobe slightly repand-dentate.

Hab.—On decayed logs, banks of Watauga R., N. C. (*Sullivant*).

** *Amphigastria with 2-3 caudæ on either side at base.*

9. **M. Bolanderi** Aust. Stems short, tumid; subflexuous, slightly twisted, nearly simple; leaves densely imbricate, dimidiate-ovate or oblong, widely spreading, nearly plane, the margin repand or in places caudato-dentate; the lobe almost separate, small, lanceolate-subulate, falcate, twisted, canaliculate, obtuse or acute, repand-undulate at the margin, sparingly caudate at the base; amphigastria scarcely wider than the stem, lingulate-ovate or oblong, obtuse or acute, the margins long decurrent, repand-undulate, caudate-lacinulate; inner involucre large, sharply 2-keeled or somewhat winged beneath, indistinctly nerved above; lower lobe of the involucral leaves acute, acuminate; capsule oval.

Hab.—Cal. (*Bolander*).
Bib.—Torrey Bull. III, 14.

XI. RADULA Nees.

Sporogonium terminal on short branches or in a fork. Inner involucre compressed or nearly terete, truncate, entire, the mouth dilated. Involucral leaves 2, deeply bilobed. Calyptra pyriform, persistent, opening below the apex. Capsule oval, 4-parted to the base. Elaters attenuate at both ends, bispiral, deciduous. Spores large, globose. Antheridia in the ventricose bases of minute perigonial leaves. Leaves 2-lobed, the small inflexed ventral producing rootlets. Amphigastria wanting. Name from Lat. *radula*, a scraper or spatula, from the form of the inner involucre.

* *Leaves rather closely imbricate or somewhat remote in No. 1.*
† *Stems dichotomously branching.*

1. **R. tenax** Lindb. Diœcious; stems brownish-green, rigid, tenacious; leaves remote, scarcely decurrent, obliquely elliptic-ovate, opaque, the cells rounded and strongly chlorophylliferous, the posterior lobe rotund-ovate, scarcely half the breadth of the stem, the interior margin free, rotund, equal to the width of the stem or more, the apex plane or scarcely incurved; male spike borne on the side of the stem below the

carina of the leaf, long linear, somewhat obtuse. (*R. pallens* Sulliv. Mosses of U. S. and Musc. Alleghan. No. 261; Aust. Hep. Bor. Amer. No. 87.)

Hab.—On rotten trunks; Md., N. C. (*Sullivant*), Catskill Mts. N. Y. (*P. T. Cleve*), mostly in mountain regions.

Bib.—Lindb. Hep. Hibern. p. 492.

Exsic.—Musc. Alleghan. No. 261; Hep. Bor.-Amer. No. 87.

†† Stems more or less pinnately branching.

‡ Mouth of inner involucre bilabiate.

2. **R. australis** Aust. Stems 1.3—2.5 cm. long, prostrate, sparingly subpinnately branched, loosely cæspitose: leaves somewhat decurrent, the lobule adnate to the stem along its inner margin; inner involucre elongate, compressed-cylindric from a pyriform or obconic base, the lips of the bilabiate mouth emarginate or crenate: male spikes short and broad, found only on the branches.

Hab.—Near Augusta, Ga. (*Sullivant*), Northern Fla. (*Austin*).

Bib.—Bot. Bulletin (now Bot. Gazette) I, 32; Torrey Bull. VI, 302.

3. **R. Caloosiensis** Aust. Stems short, somewhat rigid, closely creeping, sparingly branching, scarcely pinnate: leaves convex, entire or obscurely crenulate, obtuse, the margins mostly gemmiparous, the lower lobe rather large, somewhat acuminate or obtuse, the inner margin adnate to the stem and somewhat protracted above it; inner involucre somewhat short, from an obconic base, broadly oblong-quadrate, strongly compressed, the lips almost entire, subdecurved: male spikes rather long and loose, subinterrupted.

Hab.—Caloosa, Fla. (*Austin*).

Bib.—Torrey Bull. VI, 301.

‡‡ Mouth of inner involucre entire or crenulate.

4. **R. complanata** Dumort. Stems flat, irregularly and somewhat pinnately branched, flaccid; leaves imbricate, the dorsal lobe roundish, the ventral much smaller, triangular-ovate, appressed; inner involucre oblong, compressed, the mouth truncate, entire. (*Jungermania complanata* L.)

Hab.—On rocks and roots of trees; common. (Eu.)

Bib.—Syn. Hep. p. 257; Hep. Europ. p. 31.

Delin.—Brit. Jung. t. 81; Ekart. t. IV, f. 31.

Exsic.—Hep. Bor.-Amer. No. 85, 86.

5. **R. Hallii** Aust. Size, sporogonium and general habit like the last: leaves more incurved at the apex: inner involucre larger, elliptic-oblong, subinflated, narrower at the apex, the mouth often somewhat fleshy: involucral leaves smaller, more equally bilobed.

Hab.—Salem, Ore. (*Hall*).
Bib.—Torrey Bull. VI, 19.

6. **R. Xalapensis** Mont. Stems procumbent, densely pinnately branching, flaccid; leaves densely imbricate, orbicular, obtuse, complicate, somewhat inflated at base, the lobe broad, subrotund, produced above the stem, the margin undulate, the base acutely excised and somewhat adnate to the stem: sporogonium on a terminal or lateral branch: inner involucre elongate, funnel form, the mouth compressed, obsoletely crenate.

Hab.—On wet rocks, Tallulah Falls, Ga (*Sullivant, Lesquereux*). (Eu.)
Bib.—Syn. Hep. p. 255.
Exsic.—Hep. Bor.-Amer. No. 88b.

** *Leaves loosely imbricate.*

7. **R. Sullivanti** Aust. Stems close, subparallel, imbricate-cæspitose: branches short, diverging: leaves subimbricate, flaccid, rotund-oval, falcate, convex, more or less decurved at the apex, abruptly complicate ventrally at the base, the margin subrepand-dentate, the inferior rounded and carinate, the lobe rather small, subinflated at the apex, obtusely triangular or semicircular-rotund, the inner margin adnate to the stem and parallel with it: sporogony phase unknown.

Hab.—On rocks in mountain regions; Ga. (*Sullivant, Lesquereux*).
Bib.—Torrey Bull. VI, 19.
Exsic.—Hep. Bor.-Amer. No. 88c.

8. **R. spicata** Aust. Stems short, prostrate, strongly innovate-branching: leaves semivertical or subascending, broadly obovate, obtuse, entire, inflated at the base, very obtusely complicate for a short space then bilobed, the lobes convex on both sides, the ventral smaller by half, triangular-ovate, obtuse, adnate to the inner margin of the stem; leaves of the branches smaller, more inflated at the base: inner involucre oblong from

an obconic base, compressed, subtruncate at the apex; involucral leaves small, the lobes equal, somewhat oval; capsule oblong; spores large, fuscous, minutely papillose; male spikes 2—8 mm. long, closely leaved.

Hab.—On trees, Cal. (*Bolander*), Salem, Ore. (*Hall*).
Bib.—Torrey Bull. VI, 19.

*** *Leaves distant; inner involucre somewhat clavate.*

9. **R. obconica** Sulliv. Stems indeterminately branched; leaves distant, the dorsal lobe obovate-roundish, convex; inner involucre clavate-obconic, the mouth obliquely truncate, entire.

Hab.—On trees in cedar swamps, rare; O. (*Sullivant*), N. J. (*Austin*).
Bib.—Sulliv. Mosses U. S. p. 100.
Delin.—Sulliv. Mosses U. S. t. VIII.
Exsic.—Hep. Bor.-Amer. No. 88.

XII. BLEPHAROSTOMA Dumort.

Sporogonium terminal on the main stem or a short branch. Involucral leaves numerous, everywhere imbricate, jointed-ciliate. Inner involucre free, exserted, terete, glabrous, exceeding the calyptra, contracted and ciliate at the mouth. Capsule quadrivalved, coriaceous. Elaters bispiral, deciduous. Name from Gr. *blepharon*, an eyelid, and *stoma*, mouth, from the form of the inner involucre.

1. **B. trichophylla** Dumort. Plant minute, light-colored; stems flaccid, branched, creeping; leaves and amphigastria 3-4-parted, the divisions straight, spreading bristle-formed, each composed of a single row of cells; inner involucre terminal, ovate. (*Jungermania trichophylla* L.)

Hab.—On the ground and rotten wood, common. (Eu.)
Bib.—Syn. Hep. p. 146, 687; Hep. Europ. p. 95.
Delin.—Ekart, t. IV, f. 27.
Exsic.—Hep. Bor.-Amer. No. 84.

XIII. BLEPHAROZIA Dumort.

Diœcious. Sporogonium terminal on short branches. Involucral leaves 2-4, 4-cleft. Inner involucre terete, obovate, the mouth connivent, plicate, denticulate. Calyptra pyriform,

coriaceous. Capsule ovate, quadrivalved to the base. Ealters bispiral. Antheridia covered by closely imbricated perigonial leaves. Leaves palmatifid or complicate-2-lobed, each lobe divided and ciliate. Amphigastria 4-5-lobed. Name from Gr. *blepharon*, an eyelid, and *ozos*, a bud.

1. **B. ciliaris** Dumort. Stems crowded, somewhat pinnate; the 4-cleft leaves and amphigastria both lacerate-ciliate, the fringes long and setaceous; inner involucre obovate, the mouth contracted-plicate, laciniate-dentate. (*Jungermania ciliaris* L., *Ptilidium ciliare* Nees.)

Hab.—Roots of trees, old logs, etc., in woods or on wet rocky ground on high mountains; common. (Eu.)

Bib.—Syn. Hep. p. 250; Hep. Europ. p. 53.

Delin.—Brit. Jung. t. 65; Ekart, t. V, f. 36.

Exic.—Hep. Bor.-Amer. No. 83.

XIV. SENDTNERA Endl.

Sporogonium terminal on an elongate branch. Inner involucre tubular, deeply many-cleft. Involucral leaves numerous, incised, free or connate at the base. Calyptra chartaceous. Capsule globular. Elaters free, bispiral. Antheridia on special branches in the axils of ventricose, perigonial leaves. Leaves 2-5-cleft or entire. Amphigastria 2-many-cleft. Named for *O. Sendtner*, a German botanist.

1. **S. juniperina** Nees. Stems erect, nearly simple, slender, elongate; leaves and amphigastria nearly alike, oblong, curved and one-sided, 2-cleft to the middle, the divisions lanceolate. (*Jungermania* Swz.)

Hab.—On rocks, Catskill Mts., N. Y. (*Peck*), Greenwood Mts., N. J. (*Austin*). The European variety is now regarded as specifically distinct, *S. adunca* Gottsche (*Schisma aduncum* Dumort.).

Bib.—Syn. Hep. p. 239.

Delin.—Brit. Jung. t. 4 (?); Sulliv. Mosses U. S. t. VIII (?).

Exsic.—Hep. Bor.-Amer. No. 82.

XV. TRICHOCOLEA Dumort.

Sporogonium in a fork. Inner involucre wanting. Involucral leaves numerous coalescent into an oblong, truncate, coriaceous, hairy tube, concrete with the calyptra. Capsule oblong. Elaters free, bispiral. Antheridia on the upper side of the stem in the axils of leaves. Leaves palmately divided, the divisions laciniate. Amphigastria usually many-cleft. Name from Gr. *trichos*, hair, and *koleos*, sheath, from the form of the inner involucre. Dumortier in his later works reduces the name to Tricolea.

1. **T. tomentella** Dumort. Stems forked, 2-3-pinnately branched; leaves 4-5-divided, the divisions capillary, many-cleft; amphigastria setaceously many-cleft. (*Jungermania tomentella* Ehrh., *Tricolea tomentella* Dumort.)

Hab.—Among mosses in swamps and along rivulets; common. (Eu.)

Bib.—Syn. Hep. p. 237; Hep. Europ. p. 111.

Delin.—Brit. Jung. t. 36; Ekart. t. VI, f. 49; Sulliv. Mosses U. S. t. VIII.

Exsic.—Hep. Bor.-Amer. No. 81.

2. **T. Biddlecomiæ** Aust. Stems tender, closely creeping, simply and rather distantly pinnate; leaves transverse, split almost to the base into capillary divisions, as are also the amphigastria.

Hab.—On rotten logs in swamps, Urbana, O. (*Miss Biddlecome*).

Bib.—Bot. Gazette, III, 6.

XVI. BAZZANIA B. Gr.

Sporogonium on a branch ascending from the axil of the amphigastria. Inner involucre elongate, trigonal, obtusely trilobed, frequently more deeply fissured on one side, membranous. Involucral leaves small, narrow, subsquarrose, acutely incised at the apex. Calyptra membranous, included. Capsule globose, quadrivalved to the very base. Elaters bispiral. Antheridia spike-shaped, growing from the axils of the amphigastria. Leaves imbricate, oblique, decurved, the apex mostly tridentate rarely bifid or subentire. Amphigastria rather broad, mostly 3-4-toothed or crenate or some incised, serrate or entire. (Mastigobryum Nees, Pleuroschisma Dumort.)

1. **B. trilobata** B. Gr. Stems creeping, dichotomous-proliferous; leaves imbricate, obliquely ovate, antrorsely gibbous at the base, the apex rather broad, acutely tridentate, the teeth entire; amphigastria subrotund-quadrangular, spreading, the upper margin 4-6-toothed, the teeth subdenticulate; inner involucre curved, cylindric, plicate at the narrow apex, the mouth tridentate. (*Jungermania trilobata* L., *Pleuroschisma trilobatum* Dumort., *Mastigobryum trilobatum* Nees). A variety is *Mastigobryum tridenticulatum* Lindenb., (*Jungermania tridenticulata* Michx.)

Hab.—In ravines, wet woods and swamps; common northward and on the mountains. The variety from N. J. southward. (Eu.)

Bib.—Syn. Hep. p. 230; Hep. Europ. p. 103.

Delin.—Brit. Jung. t. 76; Ekart, t. III, f. 22; Sulliv. Mosses U. S., t. VIII.

Exsic.—Hep. Bor.-Amer. No. 77, 78, 79.

2. **B. deflexa** B. Gr. Stems narrow, forked or alternately branching; leaves strongly deflexed, cordate-ovate or ovate-oblong, falcate, arcuate at the dorsal margin, bi-tridentate or entire at the narrow apex; amphigastria somewhat approximate, suborbicular-quadrate, the upper margin bifid, crenate or entire; inner involucre cylindric, arcuate, plicate at the apex, the mouth denticulate. (*Jungermania deflexa*, Mart., *Pleuroschisma deflexum* Dumort., *Mastigobryum deflexum* Nees. Includes *Mastigobryum ambiguum* Lindenb., and *M. denudatum* Torrey MS.)

Hab.—On rocks in the higher mountains. (Eu.)

Bib.—Syn. Hep. p. 231; Hep. Europ. p. 104.

Delin.—Ekart, t. XII, f. 98.

Exsic.—Hep. Bor.-Amer. No. 80.

XVII. LEPIDOZIA Nees.

Sporogonium terminal on short branches arising from the under side of the stem. Inner involucre elongate, obtusely 3-plaited, the mouth denticulate. Involucral leaves small, rather broad, acutely 2-4-lobed at the apex. Calyptra membranous, slender, included. Capsule globose, 4-valved at the base. Elaters bispiral. Antheridia on short, spike-like branches, arising

from the underside of the stem, single in the base of conduplicate 2-3-cleft perigonial leaves. Leaves usually 4-toothed or 4-parted. Amphigastria 3-5-cleft. Name from Gr. *lepis*, a scale, and *ozos*, a bud, from the form of the involucre.

1. **L. reptans** Dumort. Stems creeping, pinnately compound or decompound, the branches often furnished with a flagellum; leaves decurved, subquadrate, acute, acutely 3-4-toothed; amphigastria subquadrate, 3-4-cleft; involucral leaves ovate, truncate, unequally 4-denticulate; inner involucre incurved, the mouth dentate. (*Jungermania reptans* L., *Pleuroschisma reptans* Dumort.)

Hab.—On the ground and on rotten wood, N. J. (*Austin*), and northward. (Eu.)

Bib.—Syn. Hep. p. 205; Hep. Europ. p. 109.

Delin.—Brit. Jung. t. 75; Ekart, t. III, f. 21; Sulliv. Mosses U. S. t. VIII.

Exsic.—Hep. Bor.-Amer. No. 75.

2. **L. setacea** Mitt. Leaves and amphigastria uniform, deeply 2-3-cleft or 3-parted, incurved, the laciniæ subulate, formed of a somewhat double series of cells: inner involucre ciliate at the mouth. (*Jungermania setacea* Web., *Blepharostoma setacea* Dumort.)

Hab.—On ground and rotten wood; common. (Eu.)

Bib.—Syn. Hep. p. 144, 686; Hep. Europ. p. 95 (sub. *Blepharostoma.*)

Delin.—Brit. Jung. t. 8; Ekart, t. IV, f. 28.

Exsic.—Hep. Bor.-Amer. No. 76.

3. **L. Californica** Aust. Stems subfiliform, flaccid, much branching; leaves loosely imbricate, deeply palmately 3-5-cleft, the laciniæ filiform-attenuate, unequal, entire or repand, or occasionally again cleft; amphigastria wider than the stem, suboblong, deeply bifid, the laciniæ incised-cilate. (*Mastigophora Californica* Aust.)

Hab.—Bark of trees, Mts. of Cal. (*Bolander*), Vancouver's Island (*Macoun.*)

Bib.—Torrey Bull. VI, 19, 302.

XVIII. CALYPOGEIA Raddi.

Inner involucre wanting. Outer involucre oblong, saccate, truncate, fleshy, hairy, attached by one side of its mouth to the stem, pendent or descending into the earth. Calyptra membranous, partly connate with the involucre. Capsule oblong, twisted, the valves narrow and contorted. Elaters bispiral. Antheridia on short, lateral, capitate branches, one in each perigonial leaf. Leaves entire or 2-toothed. Amphigastria 2-cleft. (Kantia B. Gr., Lindberg.) Name from Gr. *kalux*, a cup, *upo*, under, and *gea*, earth, from the subterranean involucre.

1. **C. trichomanis** Corda. Foliage delicate, pale-green; leaves roundish-ovate, obtuse, spreading, imbricate; involucre imbedded in the soil; ventral flagella wanting (*Jungermania trichomanis* Dicks., *Cincinnulus trichomanis* Dumort.)

Var. **rivularis** Aust. Foliage blackish or dusky-green; stems longer, more delicate; leaves more scattered, flaccid, loosely reticulate.

Var. **tenuis** Aust. Stems climbing among *Sphagna*, very slender, innovate branching; leaves smaller, usually decreasing upward, dimidiate-ovate or subfalcate, somewhat decurrent.

Hab.—On ground and rotten logs; common. (Eu.) The varieties in Southern N. J. (*Austin*).

Bib.—Syn. Hep. p. 198; Hep. Europ. p. 115 (sub. *Cincinnulus*).

Delin.—Brit. Jung. t. 79; Ekart, t. IV, f. 35; Sulliv. Mosses, U. S. t. VIII.

Exsic.—Hep. Bor.-Amer. No. 72, 73, 74.

2. **C. Sullivanti** Aust. Stems prostrate, furnished with ventral flagella; leaves flat, subcontiguous or imbricate; obliquely rotund-ovate, minutely 2-toothed at apex, the teeth usually straight, the sinus lunulate, obtuse, the inferior margin abruptly and narrowly decurrent; areolation lax, everywhere uniform; amphigastria minute, the uppermost orbicular, bifid, the medial and lower bifurcately 4-lobed, the primary lobes rotund-quadrate, strongly divaricate, the secondary ovate or subulate, usually acute.

Hab.—So. States (*Sullivant, Ravenel, Mohr.*), Delaware Water Gap, N. J. (*Austin*).

Bib.—Torrey Bull. VI, 18.

Exsic.—Hep. Bor.-Amer. No. 74b.

XIX. GEOCALYX Nees.

Inner involucre wanting. Outer involucre oblong, saccate, truncate, fleshy, naked, attached by one side of its mouth to the stem, pendent. Calyptra membranous, partly connate with the involucre. Capsule oblong. Elaters bispiral, deciduous. Antheridia on spike-like, lateral branches, in the axils of small perigonial leaves. Name from Gr. *gea*, earth, and *kalux*, a cup, from the subterranean involucre.

1. **G. graveolens** Nees. Leaves ovate-quadrate, 2-toothed, light-green; amphigastria oval-lanceolate, 2-cleft to the middle, the segments linear; involucre subterranean. (*Jungermania graveolens* Schrad.)

Hab.—On the ground in wet places; not common. (Eu.)

Bib.—Syn. Hep. p. 195; Hep. Europ. p. 118.

Delin.—Ekart, t. IX, f. 67; Sulliv. Mosses U. S., t. VII.

Exsic.—Hep. Bor.-Amer. No. 71.

XX. CHILOSCYPHUS Corda.

Sporogonium terminal on a short lateral branch. Involucral leaves 2-6, different from those of the stem, smaller. Inner involucre usually short, deeply 2-3-cleft. Calyptra globose, oblong or subclavate, slightly chartaceous. Capsule oval, quadrivalved to the base. Elaters bispiral, deciduous. Perigonial leaves like those of the stem, concealing the antheridia in their saccate bases. Leaves decurrent on the back of the stem. Amphigastria usually deeply 2-cleft, the root hairs proceeding only from their bases. Name from Gr. *cheilos*, lip, and *skuphos*, bowl, from the form of the inner involucre.

* *Amphigastria 4-parted; involucral leaves 2.*

1. **C. ascendens** Hook. and Wils. Large, pale-green; stems prostrate; leaves ascending, roundish-oblong, slightly emarginate; involucral leaves 2-cleft; inner involucres 2-3-lobed, the lobes long and irregularly lacerate-toothed. (*C. labiatus* Tayl.)

Hab.—On rotten logs, etc., rather common.
Bib.—Sulliv. Mosses U. S., p. 91.
Delin.—Sulliv. Mosses U. S., t. VIII.
Exsic.—Hep. Bor.-Amer. No. 70.

** *Amphigastria bifid; involucral leaves 2.*

2. **C. pallescens** Dumort. Stems procumbent, creeping; leaves flattened, ovate-subquadrate, retuse or obtuse; amphigastria ovate, distant, subentire, free; involucral leaves 2-toothed; inner involucre deeply trifid, the laciniæ spinose-dentate; calyptra conspicuous, mostly longer than the inner involucre. (*Jungermania pallescens* Ehrh.)

Hab.—Mts. of N. Eng. (*Oakes*). (Eu.)
Bib.—Syn. Hep. p. 187; Hep. Europ. p. 101.
Exsic.—Hep. Bor.-Amer. No. 69.

3. **C. polyanthos** Corda. Stems procumbent, creeping; leaves subascending, ovate-subquadrate, truncate-subretuse; amphigastria free, distant, ovate-oblong; involucral leaves slightly 2-toothed; inner involucre 3-lobed, the lobes short and nearly entire; calyptra longer than the inner involucre. (*Jungermania polyanthos* L.)

Var. **rivularis** Nees. Larger, more branching, succulent; leaves mostly rounded at the apex; amphigastria often divided into halves or entirely wanting, when present broader and somewhat denticulate.

Hab.—On ground and rotten logs; common. (Eu.) The variety in shady rills. (Eu.)
Bib.—Syn. Hep. p. 188; Hep. Europ. p. 101.
Delin.—Brit. Jung. t. 62; Ekart, t. VI, f. 50.
Exsic.—Hep. Bor.-Amer. No. 67, 68.

*** *Amphigastria almost entire; involucral leaves 3-4.*

4. **C. Drummondii** Tayl. Small, densely cæspitose; stems branching, prostrate, the gemmiferous ones ascending, attenuate; leaves erect-spreading, oblong, 2-cleft; amphigastria ovate, acute, connate with the adjacent pair of leaves; inner involucre terminal on short naked branches, oblong, inflated, bifid and subcompressed at the mouth, gibbous at the ventral base; involucral leaves laciniate, scale-like.

Hab.—"Bark of trees; N. A." (*Drummond*).
Bib.—Syn. Hep. p. 709.

XXI. LOPHOCOLEA Nees.

Fructification terminal on the main stem or on primary branches. Inner involucre tubular below, acutely triquetrous, more or less dilated and 3-lobed at the mouth, the lobes tooth-crested. Involucral leaves 2-4, large. Calyptra short, membranous, included, circumcissile at the base or rupturing irregularly at the apex. Capsule oval or oblong, 4-valved to the base. Elaters bispiral. Antheridia in the saccate bases of the involucral leaves. Leaves decurrent on the dorsal side of the stem, flaccid, 2-several cleft at the apex. Amphigastria 2-4 divided, the divisions more or less incised. Name from Gr. *lophos*, a crest, and *koleos*, a sheath, alluding to the crested inner involucre.

* *Divisions of amphigastria entire.*
† *Amphigastria minute.*

1. **L. bidentata** Dumort. Stems elongate, 2.5—5 cm. long, sparsely branching; leaves pale green, ovate-triangular, spreading, 2-toothed at the apex, the teeth oblique, acute, with a crescent-shaped sinus; amphigastria about 4-cleft. (*Jungermania bidentata* L.)

Hab.—On rocks in shady rills; not common. (Eu.)
Bib.—Syn. Hep. p. 159, 691; Hep. Europ. p. 83.
Delin.—Brit. Jung. t. 30; Ekart, t. VII, f. 53.

†† *Amphigastria medium size.*

2. **L. minor** Nees. Stems diffusely branching; leaves pale green, oval, subquadrate, somewhat rigid, the sinus lunate the teeth equal, acute; amphigastria one-third the size of the leaves, deeply bifid, the laciniæ lanceolate-acuminate, entire; inner involucre trigonal-plicate; involucral leaves mostly uniform.

Hab.—On roots of trees in woods. (Eu.)
Bib.—Syn. Hep. p. 160; Hep. Europ. p. 84.
Exsic.—Hep. Bor.-Amer. No. 65b.

3. **L. Macouni** Aust. Stems very short, prostrate, ascending at the apex, densely radiculose; leaves somewhat erect, ovate subquadrate, retuse or emarginate, bilobed or often entire, the margin slightly repand, the sinus and lobes obtuse; amphigastria light pink, deeply bifid, the sinus broad, obtuse, the laciniæ spreading incurved, setaceous, often formed of a single series of cells; inner involucre subobovate, slightly trigonal; involucral leaves suboblong, somewhat repand at the margin, unequally 2-4-repand-dentate at the apex.

Hab.—On logs, among other Hepaticæ, Ontario (*Macoun*), Little Falls, N. Y. (*Austin*).
Bib.—Pro. Phil. Acad. 1869, p. 223.
Exsic.—Hep. Bor.-Amer. No. 66.

** *Divisions of amphigastria somewhat dentate.*

† *Amphigastria large.*

4. **L. heterophylla** Nees. Stems short, creeping or ascending, much branched; leaves ovate-subquadrate, entire, retuse and bidentate on the same stem; amphigastria large, 2-cleft, the laciniæ slightly dentate. (*Jungermania heterophylla* Schrad.)

Hab.—On the ground and old logs, etc. in woods and swamps; very common. (Eu.)
Bib.—Syn. Hep. p. 164; Hep. Europ. p. 86.
Delin.—Brit. Jung. t. 31; Ekart, t. VII, f. 54; Sulliv. Mosses U. S. t. VII.
Exsic.—Hep. Bor.-Amer. No. 64.

†† *Amphigastria of medium size.*

5. **L. crocata** Nees. Stems creeping, branching; leaves pale, oval-subquadrangular, plane-ascending, somewhat rigid, the sinus somewhat lunate, the teeth slightly unequal, distant, acute or obtuse; amphigastria one-third as large as the leaves, ovate, deeply bifid, the laciniæ lanceolate-acuminate, extrorsely 1-toothed. (*Jungermania crocata* DeNot.)

Hab.—On ground and on dry rocks in limestone regions. (Eu.)
Bib.—Syn. Hep. p. 160; Hep. Europ. p. 85.
Exsic.—Hep. Bor.-Amer. No. 65.

6. **L. Hallii** Aust. Stems creeping, very slightly radiculose; leaves subvertical, oblong, entire or subrepand, crenulate, bilobed almost to the middle, the sinus obtuse, the laciniæ suberect, mostly obtuse; lower amphigastria small, deeply biparted, the sinus obtuse, the laciniæ subequal; upper amphigastria larger, extrorsely unidentate on both sides or palmately 3-4-parted; apical amphigastria sublanceolate, narrowly bifid, extrorsely repand-dentate.

Hab.—On the ground; Ill. (*E. Hall*).
Bib.—Pro. Phil. Acad. 1869, p. 222.

XXII. PLEURANTHE Tayl.

Fructification lateral. Inner involucre elongate-fusiform, rising from the lower side of the stem, fleshy, solid, rooting at the base, membranous above, the mouth compressed or triquetrous, 2-3-cleft, lacerate. Involucral leaves 3, minute, scale-like, 2-3-cleft. Calyptra concrete with the inner involucre except at its apex. Capsule oval. Elaters bispiral. Leaves 2-lobed or emarginate. Amphigastria lanceolate, entire. Name from Gr. *pleura*, the side, and *anthos*, flower, from the lateral fructification.

1. **P. olivacea** Tayl. Stems creeping, mostly simple, profusely rooting; leaves imbricate, rotund-oblong, somewhat emarginate; inner involucre rather large.

Hab.—"North America" (*Drummond*).
Delin.—Sulliv. Mosses U. S. t. VII.
Bib.—Syn. Hep. p. 689.

XXIII. LIOCHLÆNA Nees.

Inner involucre terminal, ascending, retrorsely subarcuate, at length cylindric, the vertex truncate, depressed plane, the mouth contracted, ciliate, the cilia articulate, connivent in a short cone. Involucral leaves 2, similar to those of the stem. Capsule oval, 4-valved to the base. Elaters inserted in the middle of the valves, bispiral. Antheridia in the axils of the unchanged upper leaves, naked. Leaves entire. Amphigastria wanting. Name from Gr. *leios*, smooth, and *chlaina*, a cloak (inner involucre).

1. **L. lanceolata** Nees. Stems closely creeping, branching; leaves entire, sometimes decurrent on the stem, the terminal ones vertically contiguous. (*Jungermania lanceolata* L., *Aplozia lanceolata* Dumort.)

Hab.—On banks and rotten logs in woods; not rare. (Eu.)
Bib.—Syn. Hep. p. 148; Hep. Europ. p. 58 (sub *Aplozia*).
Delin.—Brit. Jung. t. 28; Ekart t. I f. 7.
Exsic.—Hep. Bor.-Amer No. 62.

XXIV. ODONTOSCHISMA Dumort.

Monœcious. Fructification terminal on a short branch, arising from the ventral side of the stem. Inner involucre ascending, terete, trigonal at the apex, the mouth denticulate. Involucral leaves few, small, incised. Calyptra membranous. Capsule oblong. Elaters placed at the middle of the valves, caducous, bispiral. Antheridia in the axils of minute involucral leaves of pendent branches. Amphigastria sometimes wanting, except on gemmiferous branches. Gemmæ collected in heads upon the attenuated tips of the branches. (Sphagnœcetis Nees). Name from Gr. *odos*, *odontos*, tooth, and *schisma*, a split, from the form of the inner involucre.

1. **O. sphagni** Dumort. Stems creeping; leaves elliptic-orbicular, entire, ascending; amphigastria wanting except on fructiferous and gemmiferous stems, ovate, entire or bifid. (*Sphagnœcetis communis* Nees, *Jungermania sphagni* Dicks.)

Hab.—Among mosses; common from N. J. and O. to the Gulf of Mexico. (Eu.)

Bib.—Syn. Hep. p. 148 (sub *Sphagnœcetis*); Hep. Europ. p. 108.

Delin.—Brit. Jung. t. 33; Ekart t. VI f. 43-48.

Exsic.—Musc. Alleghan. No. 228; Hep. Bor.-Amer. No. 61.

2. **O. Macouni** (Aust). Stems stoloniferous from beneath, or innovate-branching, sparingly radiculose; leaves imbricate, oval-rotund, concave, appressed or obliquely somewhat spreading, narrowly hyaline-margined; amphigastria somewhat obsolete, ovate-lanceolate; gemmiferous branches succulent, subclavate, the leaves thin, appressed, more distinctly striolate-areolate; gemmæ pale, oval; sporogony phase unknown. (*Sphagnœcetis Macouni* Aust.)

Hab.—On damp ground near Lake Superior, Can. (*Macoun*).

Bib.—Torrey Bull. III, p. 13.

3. **O. denudata** Dumort. Stem procumbent, branching, flagelliferous, the branches ascending; leaves subvertical, connivent, orbicular, entire, decurrent toward the apex. (*O. Hubeneriana* Rabenh. Hepat. Exsic. Europ. n. 16.)

Hab.—On rotten wood, Ala. to O., N. Eng. and Canada. (Eu.)

Bib.—Hep. Europ. p. 108.

Exsic.—Hep. Bor.-Amer. No. 61b.

XXV. HARPANTHUS Nees.

Fructification on a short lateral branch. Involucral leaves smaller than those of the stem. Inner involucre distant from the outer, fusiform, thickened below, the mouth 3-4-fid, the laciniæ unequal, entire. Capsule quadrivalved to the base. Elaters bispiral. Leaves succubous, somewhat semivertical, bidentate at the apex. Amphigastria entire or nearly so. Name from Gr. *arpa*, a sickle, and *anthos*, flower, from the form of the involucre.

1. **H. scutatus** Spruce. Stems loosely creeping, ascending at the apex; leaves semivertical, suborbicular, emarginate-bidentate, the sinus semilunar, the laciniæ subequal, acute; amphigastria ovate-triangular, acute, entire or 1-2-toothed at

base; inner involucre ovate, the mouth plicate-denticulate; involucral leaves emarginate-bidentate, erect, equal. (*Jungermania scutata* Web., *Odontoschisma scutata* Aust.)

Hab.—On rotten wood in swamps and damp woods; common. (Eu.)
Bib.—Syn. Hep. p. 101; Hep. Europ. p. 67.
Delin.—Brit. Jung. t. 41; Ekart t. VIII, f. 64.
Exsic.—Musc. Alleghan. No. 224; Hep. Bor.-Amer. No. 61c.

XXVI. CEPHALOZIA Dumort.

Fructification terminal on clavate branches arising from the lower side of the stem. Inner involucre at first triquetrous, often becoming plicate, the mouth denticulate or ciliate or often laciniate. Involucral leaves numerous, enlarged, usually 2-4-cleft, in 3 or more ranks. Capsule ovate or oval, 4-valved to the base, long-pedicelled. Elaters bispiral. Antheridia in the base of inflated leaves which form a spike-like andrœcium. Leaves small, usually roundish and bidentate, with or without amphigastria. Name from Gr. *kephale*, head, and *ozos*, a bud, from the form of the fruit-bearing buds.

* *Amphigastria wanting (sometimes minute in No. 3).*
† *Leaves (at least the lower ones) distant.*

1. **C. bicuspidata** Dumort. Minute, dark green; fruit-bearing branch short; stems loose, procumbent; leaves distant or sometimes crowded, half-vertical, ovate-orbicular, usually wider than the stem, bifid to the middle with obtuse sinus and acute segments; involucral leaves in several ranks, 2-5-lobed, the lanceolate divisions repand or subdentate; inner involucre linear, complicate-triangular above, the mouth denticulate; capsule oblong, reddish brown. (*Jungermania bicuspidata* L., *Trigonanthus bicuspidatus* Spruce.)

Var. **conferta** Austin. Involucral leaves mostly bilobed, somewhat one-toothed outwardly; mouth of the inner involucre subciliate.

Hab.—On the ground in the high mountains of N. Y., N. Eng., Can. and Cal. (*Bolander*) (Eu.) The var. on banks, Closter, N. J. (*Austin*).
Bib.—Syn. Hep. p. 138; Hep. Europ. p. 91.
Delin.—Brit. Jung. t. 11; Ekart t. IV f. 33
Exsic.—Hep. Bor.-Amer. No 58, 59.

2. **C. multiflora** Lindb. Fruit-bearing branch very short; stem and sterile branches creeping, flexuous; leaves a little wider than the stem, orbicular with a broad decurrent base obliquely attached to the stem, bifid with a lunulate sinus and strongly connivent lobes; involucral leaves 2-ranked, imbricate, 3-5-fid with entire erect linear divisions; inner involucre slender, oblong, the mouth lacerate-ciliate; capsule oval, pale fuscous. (*Jungermania connivens* Dicks., *Trigonanthus connivens* Spruce, *Cephalozia connivens* Aust., *Blepharostoma connivens* Dumort.)

Hab.—On decaying moss, rotten wood and on the ground; common. Eastern U. S. to Cal. (Eu.)

Bib.—Lindb. Hep. Hibern. p. 501.

Delin.—Brit. Jung. t. 15 (exlc. f. 2, 3); Ekart t. VIII, f. 60; Sulliv. Mosses U. S. t. VII.

Exsic.—Hep. Bor.-Amer. No. 57.

3. **C. divaricata** Dumort. Plant minute, dark green; fruit-bearing branch elongate, terminal; stems usually short, rigid, with ascending branches; leaves scarcely wider than the stem, spreading, rather fleshy, oblong, bifid to the middle with acutish sinus and segments, the lower somewhat distant with entire divaricate lobes, the upper sometimes imbricate with lobes more or less serrate and not divaricate; involucral leaves 3-ranked, imbricate, 2-3-cleft, incised-dentate; inner involucre short, 4-5-angled, plicate, the scarious mouth entire or laciniate; capsule oval. (*Jungermania divaricata* Engl. Bot., *J. byssacea* Roth., *Trigonanthus divaricatus* Spruce.)

Hab.—Dry rocks in mountain woods and on dry sand, Pine Barrens, N. J. (*Austin*), and northward; also in Cal. (*Bolander*).

Bib.—Syn. Hep. p. 138 (sub *Jungermania*); Hep. Europ. p. 91.

Delin.—Brit. Jung. t. 4; Ekart, t. IV, f. 33.

Exsic.—Hep. Bor.-Amer. No. 51, 52, 53, 54.

4. **C. pleniceps** (Aust.) Stems densely cæspitose, very short, strongly radiculose beneath, with numerous ventral innovations; leaves thick, orbicular, strongly concave, vertical-connivent, somewhat half clasping but not decurrent, bifid $\frac{1}{3}$ their length, the sinus somewhat acute or obtuse; the lobes acute, incurved, strongly connivent; involucral leaves oblong,

palmately 2-4-cleft, the ventral ones amphigastria-like; inner involucre terminal on a ventral branch, large, oblong-cylindric, obtusely trigonal, the mouth plicate, denticulate. (*Jungermania pleniceps* Aust.)

Hab.—Among *Sphagna*, White Mts., N. H. (*Oakes*).
Bib.—Pro. Phil. Acad. 1869, p. 222.

†† Leaves imbricate or subimbricate.

5. **C. catenulata** Lindb. Fruit-bearing branch short: stem somewhat rigid, branching, with flexuous ascending sterile branches; leaves scarcely wider than the stem, ascending, concave, thickened at the middle, mostly bifid with a somewhat obtuse sinus and incurved segments; involucral leaves appressed, many ranked, bi-trifid, subentire; inner involucre subchartaceous, cylindric, complicate upward, the mouth ciliate; capsule oval, cinnamon-colored. (*Jungermania catenulata* Hübn.)

Hab.—On rotten wood in swamps and on the ground, N. Eng. to La.; very common southward. (Eu.)
Bib.—Syn. Hep. p. 138; Hep. Europ. p. 92.
Exsic.—Hep. Bor.-Amer. No. 56.

6. **C. curvifolia** Dumort. Fruit-bearing branch short: stems and sterile branches flexuous, creeping; leaves ascending, nearly orbicular, inflated at the ventral base, lunately 2-cleft, the segments long, linear, inflexed; involucral leaves erect, 2-3-cleft, serrate, imbricate, inner involucre elongate, narrow, the mouth denticulate; capsule oval. (*Jungermania curvifolia* Dicks., *Trigonanthus curvifolius* Spruce).

Hab.—Rotten logs in damp woods and swamps; common. (Eu.)
Bib.—Syn. Hep. p. 142; Hep. Europ. p. 93.
Delin.—Brit. Jung. t. 16.
Exsic.—Musc. Alleghan. No. 242; Hep. Bor.-Amer. No. 60.

7. **C. Macouni** Aust. Stems slender, diffusely caespitose; fruit-bearing branch short; leaves little wider than the stem, subimbricate, somewhat concave at the base, subcuneate-quadrate, bifid to below the middle, the sinus usually broad, obtuse, the segments ovate or triangular-lanceolate, acute, nearly straight, divaricate when pressed; inner involucre mi-

nute, whitish, subtrigonal, oval-obovate, subinflated, the apex contracted or subplicate, the mouth denticulate or ciliate; involucral leaves subobovate, somewhat unequal, bi-trifid, serrate, often long ciliate; capsule oval. (*Jungermania Macouni* Aust. 1869).

Hab.—On rotten logs Can. (*Macoun*), Mts. of N. Eng. (*Austin*).
Bib.—Pro. Phil. Acad. 1869, p. 222.
Exsic.—Hep. Bor.-Amer. No. 55.

** *Amphigastria present.*

8. **C. Francisci** Dumort. *var.* **fluitans** Austin. Stems very long, climbing among *Sphagna* or floating in water, flagelliferous-branching ventrally, copiously radiculose; leaves pale, loose, narrower at base, scarcely decurrent, oblong-elliptic, deeply bilobed, the margin entire, the sinus narrow, the lobes obtuse, more or less unequal, the apex incurved or flat; amphigastria minute, appressed, inconspicuous, mostly triangular-lanceolate; inner involucre short, oval, obtuse, obtusely trigonal, the mouth plicate, sublaciniate, the laciniæ truncate, naked. (*Jungermania inflata* var. *fluitans* Nees, *Cephalozia obtusiloba* Lindb.)

Hab.—Peat bogs, N. J. to Can. (Eu.)
Bib.—Bot. Bulletin (now Bot. Gazette) I, 31; Syn. Hep. p. 106; Hep. Europ. p. 89.
Exsic.—Hep. Bor.-Amer. No. 35.

9. **C. Sullivanti** Aust. Plant very minute, olive-green; stem 0.6—1.2 cm. long, fleshy, strongly radiculose, the fruit-bearing branch suberect, clavate, the sterile creeping, subfiliform or subjulaceous; leaves imbricate, often narrower than the stem, subquadrate-ovate, more or less dentato-serrate, bifid, the sinus and segments somewhat acute; inner involucre broadly oval or subobovate, obtusely and sparingly angulate, the apex slightly plicate, truncate, the mouth connivent, dentate, sometimes narrowly scarious; involucral leaves 3, erect, not grown together; capsule oval. (*Jungermania Sullivantii* Aust. 1869, *J. divaricata* Sulliv. *Musc. Alleghan.* No. 239.)

Hab.—On rotten wood, N. J., O., Ill.; rare.
Bib.—Pro. Phil. Acad. 1869, p. 221.
Exsic.—Hep. Bor.-Amer. No. 50.

10. **C. albescens** Dumort. Stems loosely creeping, arcuate, fastigiately branching; leaves subvertical, orbicular, hemispheric-concave, bifid with a short sinus, the segments equal, rather obtuse; involucral leaves uniform, mostly imbricate; amphigastria ovate- or oblong-scutiform, obtuse, entire or obtusely 1-2-toothed at the base; inner involucre oblong, smooth, the mouth contracted, denticulate. (*Jungermania albescens* Hook.)

Hab.—Ill. (*Wolf*). Greenland (*Vahl*). (Eu.)
Bib.—Syn. Hep. p. 102 (sub *Jungermania*); Hep. Europ. p. 89.

11. **C. nematodes** Gottsche. Texture lax; leaves rather long, distant; amphigastria small, 2-parted, the segments acute, their apices incurved; inner involucre on a short ventral branch.

Hab.—Banks of ditches and in swamps, Fla., Southern Ga. (*Austin*).
Bib.—Torrey Bull. VI, 302.

XXVII. COLEOCHILA Dumort.

Involucre oligophyllous, the leaves connate at the base. Inner involucre terminal, elongate, cylindric, longer than the calyptra, the mouth compressed, bilabiate. Capsule quadrivalved, coriaceous. Elaters deciduous, bispiral. Leaves entire. Amphigastria present. Name from Gr. *koleos*, sheath, and *cheilos*, lip, from the form of the inner involucre.

1. **C. Taylori** Dumort. Stems erect, nearly simple, radiculose; leaves convex, orbicular, entire, with large areolæ; amphigastria lanceolate-subulate, entire or subdentate; inner involucre terminal, oval, the mouth compressed, bilabiate; calyptra finally long exserted. (*Jungermania Taylori* Hook., *Leptoscyphus Taylori* Mitt.)

Hab.—On wet rocks, high Mts. of N. Y. and N. Eng. (*Sullivant*, *Austin*), Greenland (*Vahl*). (Eu.)
Bib.—Syn. Hep. p. 82; Hep. Europ. p. 106.
Delin.—Brit. Jung. t. 57.
Exsic.—Hep. Bor.-Amer. No. 24, 25 (?).

XXVIII. JUNGERMANIA L.

Fructification terminal on the main stem or on a short branch. Involucral leaves free, like or unlike the stem leaves. Inner involucre tubular, more or less angular, the mouth laciniate. Calyptra included, or in some species projecting. Capsule globose or oval. Elaters bispiral. Antheridia in the base of special inflated leaves. Leaves entire, bidentate, or 2-many-lobed or cleft. Amphigastria present or absent. Named for *L. Jungermann*, a German botanist of the 17th century.

(The genus as originally described by Linnæus included nearly the entire order *Jungermaniaceæ*, but has been subdivided over and over again so that its original characters are far different from those given above. The genus as given here is further broken up by recent European writers.)

* *Leaves and amphigastria uniform, 3-ranked.*

1. **J. julacea** L. Stem ascending, branching, filiform: leaves and amphigastria uniform, 3-ranked, imbricate, deeply bifid, the laciniæ oval-lanceolate, acute, somewhat serrate: inner involucre terminal, oval, plicate above, the mouth denticulate; involucral leaves more closely imbricate, larger, otherwise like those of the stem. (*Anthelia julacea* Dumort.)

Hab.—Cal. (*fide Gottsche*), Greenland (*Vahl*). (Eu.)
Bib.—Syn. Hep. p. 140; Hep. Europ. p. 98.
Delin.—Brit. Jung. t. 2; Ekart t. VIII, f. 61.

** *Amphigastria present, unlike the leaves.*
† *Leaves entire.*

2. **J. Schraderi** Mart. Stems creeping, flexuous; leaves elliptic-orbicular, entire, ascending; amphigastria broadly subulate, obsolete on old stems; involucral leaves large, elongate, entire or emarginate spreading at the apex, the inner smaller, more or less laciniate: inner involucre oval-obovate, ascending. (*Aplozia Schraderi* Dumort.)

Hab.—On the ground, rotten wood, etc.; very common. (Eu.)
Bib.—Syn. Hep. p. 83; Hep. Europ. p. 56.
Delin.—Ekart t. XI, f. 97.
Exsic.—Hep. Bor.-Amer. No. 27.

†† *Leaves bidentate.*

3. **J. Mülleri** Nees. Stems creeping, ascending at the apex, somewhat branching; leaves imbricate, semivertical, repand, obliquely ovate, emarginate-bidentate, the laciniæ unequal, acute or obtuse; amphigastria bi-trifid, subciliate at the base; involucral leaves ciliate-dentate, larger than those of the stem; inner involucre cylindric, the mouth rostrate. (*J. Bantriensis*, var. *Mülleri* Lindb.)

Var. **Danensis** Gottsche MS. is an unpublished form found in Cal. (Mt. Dana).

Hab.—Rocky Mts. (*Botanists of Wheeler Survey*). (Eu.)
Bib.—Syn. Hep. p. 99; Hep. Europ. p. 70.

4. **J. Hornschuchiana** Nees. Stems simple, radiculose, innovating from beneath; leaves semivertical, ascending, soft, orbicular, concave, bidentate with an obtuse sinus, the teeth inflexed, mostly acute; amphigastria bifid or simple, lanceolate-acuminate, ciliate-dentate at base.

Hab.—In mountains Col. (?) (*Botanists of Wheeler Survey*). (Eu.)
Bib.—Syn. Hep. p. 101; Hep. Europ. p. 69.

††† *Leaves bifid or bilobed.*

5. **J. Gillmani** Aust. Stems short, densely caespitose, prostrate, subarcuate, strongly radiculose; leaves orbicular-ovate, vertical, subconcave, bifid, the lower with sinus and teeth mostly acute, the upper much larger, more or less undulate, emarginate-bilobed, the lobes mostly rounded, the sinus obtuse; amphigastria filiform or filiform-subulate, sometimes sublanceolate, mostly entire, the broader bifid, appressed to the stem; inner involucre dorsal, sessile, without involucral leaves, vertical, obovate-lageniform, somewhat gibbous in front, the mouth ciliate, at length much incised.

Hab.—In a cave in sandstone, Traine Is. L. Superior (*Gillman*).
Bib.—Torrey Bull. III, 12.

6. **J. Wattiana** Aust. Stems rather thick, 4—8.5 mm. long, fragile, subflexuous, strongly radiculose; leaves erect-subvertical or somewhat spreading, subovate, concave, emarginate-bilobed, the lower lobe mostly acute, the upper acute or obtuse, often incurved, the sinus lunulate or angled; amphigastria

somewhat obsolete, difform, mostly hairlike or subulate, sometimes ciliate-appendiculate at the margin, the apex incurved; involucral leaves little larger, somewhat undulate, less deeply bilobed; inner involucre terminal, inflated, small, lageniform-ovate, the apex contracted, whitish, the mouth ciliate.

Hab.—On the ground in L. Superior region, Can. (*Macoun*).
Bib.—Torrey Bull. III, 11.

†††† Leaves 3-5-cleft.

7. **J. barbata** Schreb. Stems procumbent, sparingly branched; leaves roundish-quadrate, 3-5-lobed, the sinuses obtuse and undulate, the lobes obtuse, acute or mucronulate variously directed; amphigastria broad, entire or 2-toothed, sometimes obsolete; inner involucre terminal, oval, plicate-angular toward the apex, the mouth denticulate.

Var. **attenuata** Mart. Stems ascending with numerous subcylindric innovations; primary leaves semivertical, obliquely spreading, roundish, mostly concave, 2-4-toothed, the teeth acute, subequal; leaves on the innovations closely imbricate, ovate-subquadrate, premorsely 2-4-denticulate; involucral leaves 2, tridentate; inner involucre terminal, oblong, plicate at the apex. (*Jungermania attenuata* Lindenb.)

Hab.—On rocks in mountain regions; common. (Eu.)
Bib.—Syn. Hep. p. 122; Hep. Europ. p. 71, 72.
Delin.—Brit. Jung. t. 70; Ekart. t. XII, f. 102 (var.)
Exsic.—Hep. Bor.-Amer. No. 47, 48.

8. **J. setiformis** Ehrh. Stems erect or ascending, dichotomous and with the leaves terete-sulcate; leaves toothed at the base, 3-4-cleft, the lobes channeled, ovate-oblong, acute; amphigastria ciliate-dentate at the base, deeply bifid, the laciniæ lanceolate-acuminate; involucral leaves more toothed than those of the stem; inner involucral terminal, oval, plicate. (*Anthelia setiformis* Dumort.)

Hab.—Alpine summits of White Mts. N. H. (*Oakes*), Greenland (*Vahl*). (Eu.)
Bib.—Syn. Hep. p. 130; Hep. Europ. p. 97.
Delin.—Brit. Jung. t. 20; Ekart, t. II, f. 15.
Exsic.—Hep. Bor.-Amer. No. 49.

*** *Amphigastria wanting.*

† Leaves entire or nearly so.

9. **J. fossombronioides** Aust. Stems densely caespitose, ascending, strongly radiculose; leaves distichous-subvertical, closely imbricate, orbicular, the margin undulate-repand, the apex uniplicate, slightly emarginate, spreading-subrecurved, the base subcordate, clasping the stem, subventricose, radiculose; inner involucre very large, exserted, subcampanulate, 6-10-plicate, the mouth deeply laciniate, the laciniæ entire; capsule short-oval; calyptra violet.

Hab.—On rocks in a rivulet; Closter, N. J. (*Austin*).
Bib.—Pro. Phil. Acad. 1869, p. 220.
Exsic.—Hep. Bor.-Amer. No. 32.

10. **J. crenulata** Smith. Stems prostrate, branching; leaves orbicular, entire, those toward the involucre larger and bordered with large marginal cells; inner involucre obovate, compressed-4-angled, the mouth much contracted, toothed; capsule subrotund, elliptic. (*Solenostomum crenulatum* Mitt., *Aplozia crenulata* Dumort.) Var. *gracillima* (*Aplozia gracillima* Dumort.) is also found.

Hab.—On the ground in old fields, etc., N. Y. to Ala. (Eu.)
Bib.—Syn. Hep. p. 90; Hep. Europ. p. 57.
Delin.—Brit. Jung. t. 37, et Suppl. t. 1; Ekart, t. III et XII, f. 25.
Exsic.—Hep. Bor.-Amer. No. 30.

11. **J. crenuliformis** Aust. Densely cæspitose; fertile stems creeping, increasing upward, strongly radiculose, the rootlets mostly purplish; sterile stems somewhat ascending, decreasing upward; leaves orbicular, gently repand-undulate, entire or subemarginate, obliquely patent, somewhat decurrent, concave, almost cup-shaped when dry; inner involucre small, subobovate, more or less connate with the involucre, not at all or slightly exserted, radiculose at the base, at first subtriquetrous at the apex and somewhat laterally compressed, at length almost terete and somewhat beaked at the apex; capsule oval-globose; calyptra often violet purple.

Hab.—On rocks in rivulets near Closter, N. J. (*Austin*), Coshocton Co., O. (*Sullivant*).
Bib.—Torrey Bull. III, 10.
Exsic.—Hep. Bor.-Amer. No. 31.

12. **J. hyalina** Lyell. Stems creeping, strongly radiculose, branching, at length dichotomous-fastigiate, ascending; leaves semivertical, subrotund, repand and undulate, divergent-ascending; involucral leaves like those of the branches, appressed; inner involucre little exserted, ovate, acute, the apex plicate, the mouth somewhat 4-cleft; capsule globose. (*Aplozia hyalina* Dumort.)

Hab.—On banks in woods; Closter, N. J. (*Austin*), O. (*Lesquereux*). (Eu.)

Bib.—Syn. Hep. p. 92; Hep. Europ. p. 58.

Delin.—Brit. Jung. t. 63; Ekart, t. VI, f. 45.

Exsic.—Hep. Bor.-Amer. No. 28.

13. **J. biformis** Aust. Stems densely cæspitose, innovating from beneath, much branched, strongly radiculose; leaves of the stem scarcely imbricate, somewhat flattened, obliquely semicircular or broadly ovate, the dorsal margin decurrent, the apex retuse or entire, the areolation large, hyaline; leaves of the branches a half smaller, ovate or obovate, very obtuse, scarcely decurrent; sporogony phase unknown. (*Southbya biformis* Aust.)

Hab.—On steep wet rocks; Delaware Water Gap, N. J. (*Austin*).

Bib.—Pro. Phil. Acad. 1869, p. 220; Torrey Bull. VI, p. 85.

Exsic.—Hep. Bor.-Amer. No. 26.

14. **J. sphærocarpa** Hook. Stems creeping, ascending at the apex, subsimple, greenish; leaves semivertical, somewhat rigid, orbicular, obliquely spreading, decurrent dorsally at the base, pale-green; involucral leaves discrete; inner involucre exserted, obovate-oblong, the mouth 4-cleft; capsule spherical. (*Aplozia sphærocarpa* Dumort.)

Hab.—Mts. of N. Eng. (*Austin*); rare. (Eu.)

Bib.—Syn. Hep. p. 93; Hep. Europ. p. 61.

Delin.—Brit. Jung. t. 74; Ekart, t. III, f. 20.

Exsic.—Hep. Bor.-Amer. No. 29, 29b.

15. **J. cordifolia** Hook. Stems erect, fastigiately branching; leaves very lax, ovate, subrotund, not margined, erect, broadly clasping, dingy brown; involucral leaves discrete; inner involucre exserted, oblong, smoothish, the mouth minutely denticulate; capsule oval. (*Aplozia cordifolia* Dumort.)

Hab.—On the ground in moist places, Col.? (*Botanists of Wheeler Survey*), Greenland. (Eu.)

Bib.—Syn. Hep. p. 95; Hep. Europ. p. 59.

Delin.—Brit. Jung. t. 32; Ekart t. III f. 26.

16. **J. pumila** With. Stems creeping, somewhat ascending at the apex, radiculose, subsimple, pale; leaves ovate, obtuse, concave, ascending, entire; involucral leaves like those of the stem, erect; inner involucre terminal, lanceolate, plicate above, the mouth denticulate; capsule oval. (*Aplozia pumila* Dumort.)

Hab.—On shaded rocks along rivulets, Closter, N. J. (*Austin*), Col. (*Brandegee*). (Eu.)

Bib.—Syn. Hep. p. 97; Hep. Europ. p. 59.

Delin.—Brit. Jung. t. 17; Ekart, t. II, f. 13.

Exsic.—Hep. Bor.-Amer. No. 33.

†† Leaves bidentate.

17. **J. alpestris** Schleich. Stems densely creeping, bifid-branching, ascending at the apex; leaves semivertical, ovate-subquadrate, obliquely bidentate, the laciniæ unequal, acute or mucronulate, distant; involucral leaves wider than those of the stem, 2-3-cleft; inner involucre twice as long as the outer, oblong, smooth, the mouth complicate; capsule oval.

Hab.—Alpine regions of White Mts., N. H (*Oakes*). (Eu.)

Bib.—Syn. Hep. p. 113; Hep. Europ. p 75.

Exsic.—Hep. Bor.-Amer. No. 39.

18. **J. ventricosa** Dicks. Stems dense, close creeping, branching from beneath; leaves semivertical, subquadrate, plane or inflexed at the base anteriorly, broadly emarginate-bidentate, the teeth acute, often bearing globules; involucral leaves larger, erect-spreading, rotund, 3-4-cleft, somewhat dentate; inner involucre ovate, inflated, narrow-complicate toward the apex, oval. (*J. porphyroleuca* Nees is a variety *fide* Austin).

Hab.—On rotten wood and on the ground in mountainous regions and far northward; common. (Eu.)

Bib.—Syn. Hep. p. 108, 109; Hep. Europ. p. 76, 77; Pro. Phil. Acad. 1869, p. 220.

Delin.—Brit. Jung. t. 28; Ekart. t. VII, f. 58; t. X, f. 79 et. XII, f. 29 (*var.*)

Exsic.—Hep. Bor.-Amer. No. 36, 37, 38.

19. **J. Wallrothiana** Nees. Blackish, very minute; stems creeping, subsimple or innovate-branching, 1.2 mm. long, strongly radiculose; leaves wider than the stem, clasping, firm, ovate-quadrate, closely imbricate, semivertical, concave, connivent upwards, emarginate-bidentate, the sinus obtuse in the lower, acute in the upper leaves, the teeth obtuse, entire; involucral leaves larger, erect, tridentate, wavy-plicate, connate at the base; inner involucre oval-cylindric, contracted above, plicate, the mouth subdentate, pellucid, reddish below. (*Gymnocolea affinis* Dumort. var. B.)

Hab.—On coarse sand, slopes of White Mts., N. H. (*Oakes*). (Eu.)
Bib.—Syn. Hep. p. 104; Hep. Europ. p. 66.

††† *Leaves bifid or bilobed.*
‡ *Involucral leaves cleft or lobed.*

20. **J. Helleriana** Nees. Stems creeping, intricate; leaves complicate-concave, spreading, subascending, bifid $\frac{1}{2}$—$\frac{1}{3}$ their length, the lobes equal, acute, entire or serrate; involucral leaves bi-trifid, spinulose-serrate; inner involucre ovate, the mouth contracted. (*Diplophyllum Hellerianum* Dumort.)

Hab.—On rotten wood; Can., N. Y., N. Eng.; rare. (Eu.)
Bib.—Syn. Hep. p. 120; Hep. Europ. p. 50.
Delin.—Ekart t. XII, f. 103.
Exsic.—Hep. Bor.-Amer. No. 44.

21. **J. minuta** Crantz. Stems rootless; leaves complicate-concave, spreading, bifid $\frac{1}{4}$—$\frac{1}{2}$ their length, the lobes somewhat equal, ovate, acute or obtuse, entire or the gemmiferous somewhat dentate; involucral leaves trifid; inner involucre oval-oblong or subcylindric. (*Diplophyllum minutum* Dumort.)

Hab.—On rocks in high mountain regions and northward to Greenland (*Vahl*). (Eu.)
Bib.—Syn. Hep. p. 120; Hep. Europ. p. 49.
Delin.—Brit. Jung. t. 44: Ekart, t. I, f. 3.
Exsic.—Hep. Bor.-Amer. No. 45.

22. **J. polita** Nees. Stems subsimple, flexuous, blackish, ascending; leaves shining, vertical, broadly clasping, flexuous spreading, broadly cuneate-quadrate, 2-3-lobed, the margin obtusely undulate-plicate; involucral leaves 2, very broad and

short, strongly cristate-undulate, obtusely many-lobed; inner involucre terminal, elongate subcylindric, naked, the apex subplicate, the mouth minutely ciliate. (*Diplophyllum politum* Dumort.)

Hab.—In a peat bog near Closter, N. J. (*Austin*). (Eu.)

Bib.—Syn. Hep. p. 122; Hep. Europ. p. 50; Pro. Phil. Acad. 1869, p. 220.

Exsic.—Hep. Bor.-Amer. No. 46.

23. **J. inflata** Huds. Stems procumbent or ascending, loosely radiculose, branching; leaves semivertical, elliptic-subrotund, unequal-sided, unequally bilobed, the sinus and lobes obtuse; involucral leaves like those of the stem; inner involucre terminal, at length dorsal, longer than the outer, oval or pyriform, smooth, the mouth connivent; capsule oblong. (*Gymnocolea inflata* Dumort.)

Hab.—On sterile ground and on rocks, N. J. (*Austin*) and in high mountains northward to Greenland (*Vahl*). (Eu.)

Bib.—Syn. Hep. p. 105; Hep. Europ. p. 65.

Delin.—Brit. Jung. t. 38; Ekart, t. III, f. 23.

Exsic.—Hep. Bor.-Amer. No. 34.

24. **J. Sullivantiæ** Aust. Stems closely creeping, flexuous, cæspitose; leaves subovate, little wider than the stem, whitish, erect-spreading or somewhat horizontal, somewhat concave or plane, much narrowed at the base, bifid $\frac{1}{2}$—$\frac{2}{3}$ their length, the sinus obtuse, the laciniæ very acute, divergent or connivent; involucral leaves 3, larger, erect, 2-3-cleft, one of them narrower, amphigastroid; inner involucre terminal on a short ventral branch, obovate-oblong, strongly plicate, at first triquetrous, at length terete, the mouth deeply about 10-cleft with the same number of folds; the laciniæ subconnivent, serrate or subentire.

Hab.—On rotten wood, O. (*Sullivant*), Ill. (*Hall*).

Bib.—Torrey Bull. III, 12.

‡‡ *Involucral leaves merely toothed.*

25. **J. excisa** Dicks. Stems subsimple, short, closely creeping, somewhat rigid; leaves semivertical, erect-spreading, subrotund, pellucid, inflexed at the base anteriorly, the sinus deep, obtuse, the excised laciniæ straight, acute; involucral

leaves erect, quadrate, usually 4-5-toothed; inner involucre erect, oblong, pale with a rosy band and spots, plicate above, the mouth truncate, irregularly denticulate.

Var. **crispa** Hook. Leaves quadrate-subrotund, closely imbricate, deeply and obtusely emarginate-bi-trifid; involucral leaves 3-4-cleft, subserrate, connate at base. (*J. intermedia* Lindenb.)

Hab.—Sterile ground in open woods; common. (Eu.) The *var.* in rock crevices near the Passaic, Hudson and Delaware Rivers (*Austin*).

Bib.—Syn. Hep. p. 112, 117; Hep. Europ. p. 76, 78.

Delin.—Brit. Jung. t. 9; et Suppl. t. 2 *var.;* Ekart, t. IV, f. 29; et t VI et XII, f. 46.

Exsic.—Hep. Bor.-Amer. No. 40, 41.

26. **J. incisa** Schrad. Stems thick, closely creeping or ascending, radiculose; leaves densely crowded, somewhat quadrate, complicate, semivertical, 2-6-cleft, the laciniæ unequal, acute, more or less spinulose-dentate; involucral leaves similar, more plicate and dentate, free; inner involucre short, oval or obovate, the mouth plicate, denticulate.

Hab.—On rotten wood in mountainous regions and northward. (Eu.)

Bib.—Syn. Hep. p. 118; Hep. Europ. p. 80.

Delin.—Brit. Jung. t. 10; Ekart, t. IV, f. 59, et t. X, f. 77.

Exsic.—Hep. Bor.-Amer. No. 42.

27. **J. Michauxii** Web. Stems ascending, flexuous by repeated innovations from beneath the summit; leaves subvertical, crowded, erect-spreading, somewhat saccate at the base, subquadrate, bifid, the sinus narrow, the lobes acute not curved; involucral leaves similar to those of the stem, the outer serrulate, the inner smaller; inner involucre oval-subclavate, obtuse, plicate at the apex, the mouth fringed.

Hab.—On fallen trunks, etc. Mts. of N. Y. and N. Eng.; common. (Eu.)

Bib.—Syn. Hep. p. 119; Hep. Europ. p. 81.

Exsic.—Musc. Alleghan. No. 236; Hep. Bor.-Amer. No. 43.

28. **J. Dicksoni** Hook. Stems prostrate, copiously rooting beneath, somewhat simple, the apex ascending; leaves spreading from a somewhat erect base, somewhat involute

when dry, pale brown or becoming whitish, deeply 2-lobed, the lower lobe obliquely ovate or ovate-lanceolate or falcate, mostly acute, subrepand or subserrate and somewhat margined on the ventral side toward the base; the uper lobe a half smaller, lanceolate, acute; cells rather large, roundish, nearly uniform: inner involucre ovate, the mouth plicate-laciniate. (*Diplophyllum Dicksoni* Dumort.)

Hab.—Mendocino City, Cal. (*Bolander*). (Eu.)
Bib.—Syn. Hep. p. 77; Hep. Europ. p. 49.
Delin.—Brit. Jung. t. 48; Ekart, t. IX, f. 68

29. **J. rubra** Gottsche MS.,

30. **J. Danicola** Gottsche MS., and

31. **J. Bolanderi** Gottsche MS. are unpublished species from California.

XXIX. SCAPANIA Dumort.

Monœcious or diœcious. Inner involucre terminal, compressed parallel to the plane of the stem, the apex usually decurved and the mouth truncate entire or ciliate. Involucral leaves 2, larger and usually more denticulate than those of the stem. Calyptra membranous. Capsule oval. Elaters long, inserted in the middle of the valves, bispiral, deciduous. Antheridia 3-20, in the axils of small saccate leaves which are scarcely imbricate or crowded into terminal heads. Leaves complicate-2-lobed, the dorsal lobe usually smaller. Amphigastria wanting. (Martinellia B. Gr. in part.) Name from Gr. *skapanion*, a hoe or shovel, from the shape of the inner involucre.

* *Lobes of leaves subequal.*

1. **S. subalpina** Nees. Leaves denticulate outwardly, equidistant, imbricate, bifid almost to the middle, the lobes subrotund, obtuse; inner involucre very much longer than the outer, obovate from a narrow base, compressed, truncate, denticulate.

Hab.—Mts. of N. Eng. (*Oakes, Austin*); near L. Superior (*Gillman*): rare. (Eu.)
Bib.—Syn. Hep. p. 64, 661; Hep. Europ. p. 36.
Delin.—Ekart, t. XI, f. 91.
Exsic.—Hep. Bor.-Amer. No. 15b.

2. **S. glaucocephala** Aust. Stems small, cæspitose, somewhat simple, creeping or ascending, producing numerous suckers; leaves entire, obtusely complicate-bilobed, the lobes broadly ovate, mostly obtuse and apiculate; involucral leaves uniform, some of them somewhat denticulate; inner involucre small, subcuneate, strongly compressed, the mouth truncate, entire, often somewhat recurved. (*S. Peckii* Aust., *Jungermania glaucocephala* Tayl.)

Hab.—On rotten wood, Canada (*Macoun*), N. Y. (*Peck*), N. Eng. (*Austin*).

Bib.—Syn. Hep. p. 684 (sub *Jungermania*); Pro. Phil. Acad. 1869, p. 218; Torrey Bull. VI, 85.

Exsic.—Hep. Bor.-Amer. No. 20.

** *Ventral lobes about double the size of the dorsal (except in upper leaves of No. 8).*

† *Margins of leaves subentire.*

3. **S. albicans** Mitt. *var.* **taxifolia.** Stems ascending, almost rootless; leaves closely complicate-bifid, subdenticulate, either wholly evittate or with only a rudimentary vitta near the base, the lobes obtuse or somewhat acute, the ventral oblong-acinaciform, the dorsal subovate; inner involucre ovate-plicate. (*Jungermania albicans* L. var. *taxifolia*, *Diplophyllum taxifolium* Dumort. A smaller form is *J. obtusifolia* Sulliv. Musc. Alleghan. No. 230, not of Hook.)

Hab.—Under rocks in mountain ravines, the smaller form also on the ground. (Eu.)

Bib.—Syn. Hep p. 76 (sub *Jungermania*); Hep. Europ. p. 49 (sub *Diplophyllum*).

Exsic.—Musc. Alleghan. No. 229, 230; Hep. Bor.-Amer. No. 22, 23.

4. **S. compacta** Dumort. *var.* **irrigua.** Stems creeping; leaves repand, somewhat rigid, deeply unequally bilobed, the lobes rounded, submucronate, the ventral appressed, the dorsal half as large, convex, with incurved apex; involucral leaves bifid, the lobes subequal, denticulate; inner involucre ovate, subcompressed-angular, the mouth denticulate. (*Jungermania irrigua* Nees, *S. irrigua* Dumort.)

Hab.—In wet places, Mts. of N. Eng. (*Oakes*), Catskill Mts (*Austin*), Canada (*Macoun*), near Tom's R., N. J. (*Austin*). (Eu.)

Bib.—Syn. Hep. p. 67; Hep. Europ. p. 37.

Exsic.—Hep. Bor.-Amer. No. 15c.

†† *Margins of leaves serrate-dentate.*

5. **S. Oakesii** Aust. Leaves obovate, somewhat spreading, often deflexed, convex, closely complicate-bilobed, the lobes obtuse, serrate-dentate, the upper twice as large, coarsely dentate on the margin and the carina with deep purple spur-like teeth, the dorsal lobe subrotund, less dentate; inner involucre compressed, the mouth truncate, usually dentate.

Hab.—White Mts., N. H. (*Oakes, Austin*), Observatory Inlet (*Douglas*).
Bib.—Torrey Bull. III, p. 10.
Exsic.—Hep. Bor.-Amer. No. 14.

††† *Margins of leaves ciliate-dentate.*

6. **S. nemorosa** Nees. Stems ascending, crowded; leaves unequally complicate-bilobed, the lobes convex, obtuse, ciliate-dentate, the ventral obovate, oblique, twice as large as the dorsal; texture rather fine; inner involucre ciliate at the mouth. (*Jungermania nemorosa* L.)

Hab.—On rocks and on the ground in swamps, etc.; common, very variable. (Eu.)
Bib.—Syn. Hep. p. 68; Hep. Europ. p. 38.
Delin.—Brit. Jung. t. 21 (excl. f. 1, 8, 17-19); Ekart, t. II, f. 10.
Exsic.—Musc. Alleghan. No. 224, 225, 226; Hep. Bor.-Amer. No. 16, 17, 18.

7. **S. Bolanderi** Aust. Stems somewhat dichotomous, cæspitose, ascending; leaves acutely complicate, coarsely ciliate-dentate, the ventral lobe strongly convex, obliquely obovate-oblong, round-obtuse, decurved-spreading, the dorsal a half shorter, not narrower, less convex, orbicular or broadly ovate, erect-subvertical or somewhat appressed, the apex somewhat acute, more coarsely dentate, slightly incurved, the outer margin produced at the base into long deflexed often compound cilia; inner involucre compressed, oblong, the mouth subciliate. (*S. Californica* Gottsche in Bolander's Cat.)

Hab.—Redwood trees, Cal. (*Bolander*), Oregon and Br. Col. (*Scouler*), Vancouver's Island (*Douglas*).
Bib.—Pro. Phil. Acad. 1869, p. 218; Torrey Bull. VI, 85.
Exsic.—Hep. Bor.-Amer. No. 19.

8. **S. undulata** Nees and Mont. Stems erect, subdichotomous; leaves lax, spreading, entire or ciliate-denticulate, the lobes round-trapezoidal, the dorsal half as large except at the

summit of the stem where they are equal; texture thin, flaccid; inner involucre twice the length of the outer. (*Jungermania undulata* L.)

Var. **purpurea** Nees. Stems elongate, rather more lax; leaves rose-colored or purplish, flaccid.

Hab.—In woods, damp meadows and rills, Eastern U. S. and Cal. (*Bolander*). (Eu.)

Bib.—Syn. Hep. p. 65; Hep. Europ. p. 37.

Delin.—Brit. Jung. t. 22; Ekart, t, II, f. 14.

Exsic.—Hep. Bor.-Amer. No. 12, 13.

*** *Ventral lobe 3-4 times the size of the dorsal.*

† *Margins entire.*

9. **S. exsecta** Aust. Stems ascending; leaves somewhat complicate, entire, the dorsal lobe small, tooth-like, the ventral ovate, acute or bidentate, concave; involucral leaves 3-5-cleft; inner involucre oblong, obtuse, plicate. (*Jungermania exsecta* Schmid.)

Hab.—On high mountains far northward; rare. (Eu.)

Bib.—Syn Hep. p. 77 (sub. *Jungermania*); Hep. Europ. p. 73 (sub *Jungermania*).

Delin.—Brit. Jung. t. 14; Ekart, t. V. f. 37, et t. XI.

Exsic.—Hep. Bor.-Amer. No. 21.

10. **S. uliginosa** Nees. Stems frequently floating, erect when terrestrial; leaves entire, somewhat rigid, deeply and unequally bilobed, the lobes rotund, the ventral convex, spreading, about four times as large as the dorsal, the dorsal lobe reniform, arched, incumbent; involucral leaves uniform with those of the stem, the lobes entire; inner involucre larger than the outer. (*Jungermania uliginosa* Swz.)

Hab.—Col. (*Botanists of Wheeler's Sur.*), Greenland (*Syn. Hepat.*) (Eu.)

Bib—Syn. Hep. p. 67; Hep. Europ. p. 39.

†† *Margins serrate or dentate.*

11. **S. breviflora** Tayl. Stems ascending; leaves dentate, deeply 2-lobed, the lobes triangular, the dorsal springing from the plane of the ventral near its dorsal margin, the ventral about four times as large; inner involucre as long as the

outer, obconic, plicate, compressed, shortly 4-laciniate and dentate at its mouth, its narrow base surrounded by lanceolate serrate scales.

Hab.—Near Philadelphia, Pa. (*Dr. Watson*)
Bib.—Syn. Hep. p. 661.

12. **S. umbrosa** Nees. Stems somewhat erect, branching; leaves unequally conduplicate-bilobed, the lobes ovate, acute, serrate, the ventral three times as large as the imbricate dorsal lobes; inner involucre naked at the mouth. (*Jungermannia umbrosa* Schrad.)

Hab.—White Mts,, N. H.; rare. (Eu.)
Bib.—Syn. Hep. p. 69; Hep. Europ. p. 38.
Delin.—Brit. Jung. t. 24 et Suppl. t. 3; Ekart. t. II, f. 12.
Exsic.—Hep. Bor.-Amer. No. 15.

XXX. PLAGIOCHILA Dumort.

Fructification terminal or lateral. Inner involucre compressed at right angles to the plane of the stem, the mouth truncate, entire or ciliate-toothed. Involucral leaves 2, larger than those of the stem. Calyptra membranous. Capsule oval. Elaters inserted in the middle of the valves, long, bispiral, deciduous. Antheridia covered by small ventricose imbricate leaves. Leaves with the dorsal margin decurrent and deflexed, often turned to one side. Name from Gr. *plagios*, sideways, and *cheilos*, a lip, from the shape of the inner involucre.

* *Ventral margins of the leaves decurrent and forming two parallel crestlike lines on under side of stem.*

1. **P. Ludoviciana** Sulliv. Main branches ascending, flexuous, sparingly ramulose; leaves patent-divergent, semiovate, 2-3-dentate at the apex, the dorsal margins reflexed, entire, the ventral spinulose-dentate; amphigastria deeply 2-3-cleft, the segments ciliate-dentate.

Hab.—On the bark of trees, La. and Ala. (*Sullivant*).
Bib.—Syn. Hep. p. 660; Amer. Jour. Sci. and Arts, 1846, p. 73.
Exsic.—Musc. Alleghan. No. 223; Hep. Bor.-Amer. No. 11.

2. **P. undata** Sulliv. Like No. 1 but more rigid, with simple branches: leaves horizontal, triangular-ovate, obtuse, emarginate, or sparingly dentate at the apex, the dorsal margins reflexed and entire, the ventral repand-undulate; amphigastria 2-cleft, the segments dentate.

Hab.—Shaded banks of rivers and wet rocks, Ga. (*Sullivant, Lesquereux*).

Bib.—Syn. Hep. p. 659; Amer. Jour. Sci. and Arts, 1846, p. 73.

Exsic.—Musc. Alleghan. No. 222; Hep. Bor.-Amer. No. 10.

** *Under side of stems without crestlike lines.*

† *Amphigastria 2-3-cleft, fugacious.*

3. **P. porelloides** Lindenb. Stems divided, the branches ascending; leaves somewhat imbricate, convex-gibbous, obovate-rotund, those near the summit of the stem repand-denticulate, the others entire, the dorsal margin reflexed; inner involucre terminal, oblong-ovate, the mouth compressed, denticulate. (*Jungermania viticulosa* Schwein.) A variety is *P. nodosa*, Tayl.

Hab.—Among mosses in swamps and rivers; common. The *var.* in mountain ravines, Canada, N. Eng., N. J. (*Austin*).

Bib.—Syn. Hep. p. 48, 645.

Exsic.—Musc. Alleghan. No. 220; Hep. Bor.-Amer. No. 7, 7b.

4. **P. interrupta** Dumort. Stems prostrate, copiously rooting, branched, the branches horizontal; leaves imbricate, oval, horizontal, entire or slightly repand; amphigastria lanceolate, 2-3-cleft; inner involucre terminal, broadly obconic, the mouth compressed, repand-crenulate. (*P. macrostoma* Sulliv., *Jungermania interrupta* Nees.)

Hab.—On moist banks and decayed logs; O. (*Sullivant*), N. Eng. (*Oakes*), Greenland (*Vahl*). (Eu.)

Bib.—Syn. Hep. p. 48, 659; Hep. Europ. p. 44; Sulliv. Mosses U. S. p. 96; Torrey Bull. VI, 85.

Delin.—Sulliv. Mosses U. S. t. VIII.

Exsic.—Musc. Alleghan No. 221; Hep. Bor.-Amer. No. 6.

†† *Amphigastria wanting.*

5. **P. spinulosa** Nees and Mont. Stems creeping, the branches ascending; leaves remote, obliquely spreading, obovate-cuneate, the dorsal margin reflexed, entire, the ventral and apex spinulose-toothed; inner involucre subrotund, at length oblong, the mouth spinulose. (*Jungermania spinulosa* Dicks.)

Hab.—Shaded rocks in mountain regions; rare. (Eu.)
Bib.—Syn. Hep. p. 25; Hep. Europ. p. 44.
Delin.—Brit. Jung. t. 14; Ekart, t. II, f. 10.
Exsic.—Hep. Bor.-Amer. No. 9.

6. **P. asplenoides** Nees and Mont. Stems creeping, branched; leaves somewhat imbricate, obliquely spreading, obovate-rotund, entire or denticulate, the dorsal margin reflexed; inner involucre much exceeding the outer, terminal, oblong, dilated and compressed at the apex, the mouth truncate, ciliate. (*Jungermania asplenoides* L.)

Hab.—In rocky rivulets; common. (Eu.)
Bib.—Syn. Hep. p. 49; Hep. Europ. p. 43.
Delin.—Brit. Jung. t. 13; Ekart, t. I, f. 4.
Exsic.—Hep. Bor.-Amer. No. 8.

XXXI. NARDIA B. Gr.

Fructification terminal, inner involucre 6-toothed, included in the outer and connate with it excepting the teeth. Involucral leaves united nearly to the top into an oblong tube. Capsule globose, 4-valved or sometimes opening irregularly, pedicelled. Elaters bispiral. Antheridia in the saccate base of leaves on the back of the stem. Leaves 2-lobed or emarginate. Amphigastria rarely present. Stems often sending out flagella from their base. (Sarcoscyphus Corda. Alicularia Corda.)

* *Amphigastria wanting.*

† *Leaves imbricate, at least the upper.*

‡ *Areolation of leaves very large.*

1. **N. Bolanderi** Aust. Small, densely cæspitose, varying from dark lurid green to blackish; stems entangled with numerous rootlets, creeping, the apex ascending, clavate; lower leaves distant, scarcely broader than the stem, subvertical, spreading, the upper imbricate, much larger, erect-spreading,

all round-ovate, obscurely margined, emarginate-bilobed at the apex $\frac{1}{4}$—$\frac{1}{3}$ their length, the sinus acute or somewhat obtuse, the lobes strongly obtuse. (*Sarcoscyphus Bolanderi* Aust.)

Hab.—Exposed rocks, Mts. of Cal. (*Bolander*).
Bib.—Torrey Bull. III, 9.
Exsic.—Hep. Bor.-Amer. No. 4b.

‡‡ *Areolation moderate.*

2. **N. adusta** Aust. Stems very short, creeping at their base; branches ascending, subclavate, terete, straight; leaves ovate, closely imbricate, bifid at the apex, the margins pellucid punctate. (*Gymnomitrium adustum* Nees, *Acolea brevissima* Dumort., *Sarcoscyphus adustus* Aust.)

Hab.—Alpine regions of White Mts., N. H. (*Oakes*, *Austin*). (Eu.)
Bib.—Syn. Hep. p. 3 (sub *Gymnomitrium*); Hep. Europ. p. 123 (sub *Acolea*).
Exsic.—Hep. Bor.-Amer. No. 4.

3. **N. emarginata** B. Gr. (?) Stems somewhat erect, mostly dichotomous; leaves erect, approximate, embracing the stem by their broad base, somewhat quadrate; lobes obtuse, the foliage dark green or brownish purple. (*Jungermania emarginata* Ehrh., *Marsupella emarginata* Dumort., *Sarcoscyphus Ehrhartii* Corda, *S. emarginatus* Boul.)

†† *Leaves distant.*

Var. **aquatica** (Nees). Stems elongate somewhat floating; leaves spreading, more scattered.

Hab.—On wet rocks chiefly in high mountain rivulets, N. Y., N. Eng. (Eu.)
Bib.—Syn. Hep. p. 6 (sub *Sarcoscyphus Ehrhartii*); Hep. Europ. p. 126 (sub *Marsupella*).
Delin.—Brit. Jung. t. 27; Ekart, t. VII, f. 56.
Exsic.—Hep. Bor.-Amer. No. 2, 3.

4. **N. sphacelata** B. Gr. (?) Stems erect, somewhat branched; leaves obovate-rotund, narrower at the base, embracing the stem, the apical sinus somewhat obtuse, the laciniæ rounded, sphacelate at the apex. (*Jungermania sphacelata* Gieseke, *Sarcoscyphus sphacelatus* Nees, *Marsupella sphacelata* Dumort.)

Hab.—Wet rocks, Mts. of N. Eng. to N. J. and southward; also Greenland. (Eu.)

Bib.—Syn. Hep. p. 7; Hep. Europ. p. 127 (sub *Marsupella*).

Delin.—Ekart, t. XI, f. 91.

Exsic.—Musc. Alleghan. No. 216; Hep. Bor.-Amer. No. 3b.

** *Amphigastria triangular-subulate.*

5. **N. Lescurii** (Aust.) Stems prostrate, copiously radiculose beneath as well as the usually emarginate-bilobed leaves; areolation lax; amphigastria entire or the uppermost subdentate. (*Alicularia Lescurii* Aust.)

Hab.—Wet rocks, Tallulah Falls, Ga. (*Lesquereux*, 1850).

Bib.—Torrey Bull. VI, 18.

Exsic.—Hep. Bor.-Amer. No. 5.

XXXII. CESIA B. Gr.

Involucral leaves numerous, imbricate. Inner involucre wanting. Calyptra immersed in the involucral leaves. Capsule quadrivalved, coriaceous. Elaters bispiral, deciduous. Leaves closely imbricate. Amphigastria wanting. (Acolea Dumort.)

1. **C. concinnata** B. Gr. Stems intricately branching, thickened at the apex; leaves closely imbricate, ovate, the apex bifid, with a narrow scarious margin. (*Jungermania concinnata* Lightf., *Gymnomitrium concinnatum* Corda, *Acolea concinnata* Dumort.)

Hab.—Alpine regions of White Mts., N. H. (*Oakes*). (Eu.)

Bib.—Syn. Hep. p. 3 (sub *Gymnomitrium*); Hep. Europ. p. 122 (sub *Acolea*).

Delin.—Brit. Jung. t. 3; Ekart, t. VIII, f. 63.

Exsic.—Hep. Bor.-Amer. No. 1.

APPENDIX A.

The geographic distribution of the American Hepaticæ may be represented as follows. It must be remembered that the table is made from incomplete data, and will be necessarily changed as further knowledge of our species is received.

Species common to America and Europe are italicized. Those followed by the letter L. have been found in only a very limited territory. Those marked with a (*) are reported from Illinois.

I. Boreal.

Fimbriaria pilosa.
Fossombronia Macouni.
Frullania Oakesiana.
*F. æolotis.
F. Hutchinsiæ.
Bazzania deflexa.
Chiloscyphus pallescens.
Odontoschisma Macouni.
Cephalozia Macouni.
C. pleniceps.
**Coleochila Taylori?*
Jungermania alpestris.
J. cordifolia.
J. Gillmani.
J. Hornschuchiana.
J. incisa.
J. inflata.
J. Michauxii.
J. Wattiana.
J. minuta.
J. setiformis.
J. sphærocarpa.
J. ventricosa.
J. Wallrothiana.
Scapania albicans, var. *taxifolia.*
S. compacta, var. *irrigua.*
S. exsecta.
S. Oakesii.
S. glaucocephala.
S. subalpina.
S. uliginosa.
S. umbrosa.
Plagiochila interrupta.
P. spinulosa.
Nardia adusta.
N. emarginata.
N. sphacelata.
Cesia concinnata. — 38.

II. Medial.

*Riccia Frostii.
R. Watsoni.
R. Beyrichiana. L.
R. bifurca?
R. arvensis. L.
*R. Lescuriana.
*R. lutescens.
R. tenuis.
**R. natans.*
Preissia hemispharica.
**Grimaldia barbifrons.*
Duvalia rupestris.
**Asterella hemispharica.*
*Fimbriaria tenella.
Aitonia erythrosperma. L.
*Notothylas orbicularis.
N. melanospora.
**Aneura multifida.*
A. palmata.
**A. pinguis.*
A. pinnatifida. L.
*A. sessilis.
Pellia epiphylla.
P. calycina.
Blasia pusilla.
Steetzia Lyellii.
Metzgeria myriopoda.
M. conjugata.
M. pubescens.
M. hamata.
Fossombronia angulosa.
F. cristula. L.
F. pusilla.
*Frullania Eboracensis.
F. Pennsylvanica.
*F. Grayana.
F. plana.
F. saxicola.
F. tamarisci?
*F. Virginica.
F. fragilifolia. L.
Lejeunia calyculata.
L. serpyllifolia, var. Americana.
L. cucullata.
L. cyclostipa. L.
L. echinata.
L. polyphylla. L.
L. testudinea. L.
Phragmicoma clypeata.
Madotheca platyphylla.
**M. porella.*
M. Sullivanti.
**M. thuja.*
**Radula complanata.*
R. obconica.
R. tenax.
**Blepharostoma trichophylla.*
**Blepharozia ciliaris.*
Sendtnera juniperina.
Trichocolea tomentella.
T. Biddlecomiæ. L.
Bazzania trilobata.
Lepidozia reptans.
L. setacea.
**Calypogeia trichomanis.*
Geocalyx graveolens.
*Chiloscyphus ascendens.
C. Drummondii?
C. polyanthus.
**Lophocolea bidentata.*
L. crocata.
L. Hallii.
**L. heterophylla.*

*L. Macouni.
**L. minor.*
Pleuranthe olivacea.
Liochlæna lanceolata.
**Harpanthus scutatus.*
Odontoschisma denudata.
**Cephalozia curvifolia.*
*C. Sullivanti.
**C. albescens.* ?
C. Francisci, var. *fluitans.*
Jungermania barbata.
J. biformis. L.
J. crenulata.
J. crenuliformis. L.
J. excisa.
J. fossombronioides. L.
J. Helleriana.
**J. hyalina.*
J. pumila.
J. polita.
**J. Schraderi.*
J. Sullivantiæ.
Scapania breviflora. L.
**S. nemorosa.*
Plagiochila asplenoides.
P. porelloides. = 99.

III. Austral.

Riccia albida.
R. Donnellii.
Thallocarpus Curtisii.
Sphærocarpus Michelii.
S. Texanus.
S. Donnellii.
Marchantia disjuncta. L.
Dumortiera hirsuta.
Fimbriaria elegans.
F. fragrans.
Aitonia Wrightii.
Anthoceros Donnellii. L.
A. Mohrii.
**A punctatus.*
A. Ravenelii.
A. Olneyi.
Fossombronia Cubana.
Frullania brunnea. L.
F. Donnellii.
*F. squarrosa.
F. Kunzei.
F. Sullivantii.
F. Wrightii.
Lejeunia auriculata.
L. Caroliniana. L.
L. longiflora.
L. Jooriana.
L. minutissima.
L. Mohrii.
L. Austini.
L. læte-fusca.
L. Ravenelii.
Phragmicoma xanthocarpa.
Madotheca involuta.
M. Wataugensis. L.
Radula australis.
R. Caloosiensis.
R. Sullivantii.
R. Xalapensis. L.
Calypogeia Sullivanti.
Odontoschisma sphagni.
Cephalozia catenulata.
C. nematodes.
Plagiochila Ludoviciana.
P. undata.
Nardia Lescurii. = 46.

IV. Occidental.

Riccia glauca.
R. Californica.
R. ciliata.
R. intumescens.
Sauteria limbata.
Grimaldia Californica.
Cryptomitrium tenerum.
Fimbriaria Bolanderi.
F. Californica.
F. violacea.
Targionia hypophylla.
Anthoceros Hallii.
A. cæspiticius.
A. Oreganus.
A. sulcatus.
A. fusiformis.
A. stomatifer.
Fossombronia longiseta.
Frullania Bolanderi.
F. Hallii.
F. Nisquallensis.
Madotheca Bolanderi.
M. navicularis.
Radula Hallii.
R. spicata.
Lepidozia Californica.
Jungermania Bolanderi.
J. Mülleri. ?
J. Dicksoni.
J. Danicola.
J. julacea.
J. rubra.
Scapania Bolanderi.
Nardia Bolanderi. — 34.

V. Cosmopolitan.

**Riccia sorocarpa.*
R. lamellosa.
R. nigrella.
**R. fluitans.*
R. crystallina.
**Marchantia polymorpha.*
**Conocephalus conicus.*
Lunularia cruciata. Introd.
**Anthoceros lævis.*
Madotheca rivularis.
**Cephalozia divaricata.*
**C. bicuspidata.*
**C. multiflora.*
Scapania undulata. — 14.

APPENDIX B.

In order to make more widely known the classification adopted by Lindberg the following schedule is given:

GENERA EUROPÆA HEPATICARUM.

ORDER I. MARCHANTIACEÆ.

A. *Schizocarpæ.*

1. Marchantieæ.

1. Marchantia.
2. Preissia.
3. Conocephalus.
4. Fimbriaria.
5. Duvalia.
6. Asterella.
7. Dumortiera.
8. Santeria.
9. Clevea.
10. Aitonia.
11. Lunularia.

2. Targionieæ.

12. Targionia.

B. *Cleistocarpæ.*

3. Corsinieæ.

13. Corsinia.
14. Tessellina.

4. Riccieæ.

15. Riccia.

Order II. Jungermaniaceæ.

A. *Schizocarpæ.*

* Anomogamæ.

1. Frullanieæ.

1. Frullania.
2. Lejeunia.
3. Radula.
4. Porella.
5. Pleurozia.

2. Metzgerieæ.

6. Metzgeria.

** Homogamæ.

† Opisthogamæ.

3. Lepidozieæ.

7. Lepidozia.
8. Bazzania.
9. Odontoschisma.
10. Cephalozia.
11. Lophocolea.
12. Pedinophyllum
13. Chiloscyphus.
14. Harpanthus.

4. Saccogyneæ.

15. Kantia.
16. Saccogyna.

5. Riccardieæ.

17. Riccardia.

†† Acrogamæ.

18. Trichocolea.
19. Blepharozia.
20. Mastigophora.
21. Herberta.
22. Anthelia.
23. Blepharostoma

7. Jungermanieæ.

24. Martinellia.
25. Diplophyllum.
26. Plagiochila.
27. Mylia.
28. Southbya.
29. Jungermania.
30. Nardia.
31. Cesia.

8. Acrobolbeæ.

32. Acrobolbus. 33. Calypogeia.

9. Fossombronieæ.

34. Scalia.
35. Fossombronia.
36. Petalophyllum.
37. Pallavicinia.
38. Blasia.
39. Pellia.

B. *Cleistocarpæ.*

10. Sphærocarpeæ.

40. Durieua. 41. Sphærocarpus.

11. Thallocarpeæ.

42. Thallocarpus.

Order III. Anthocerotaceæ.

1. Anthoceroteæ.

1. Anthoceros. 2. Notothylas.

APPENDIX C.

For another form of synoptical table, as well as the outline of another classification, the following translation from *Hepaticæ Europæ*, by Dumortier, is added. It will be seen to be based entirely on the fructification. All of Dumortier's genera of foliose *Jungermaniaceæ* are given.

SYNOPSIS OF TRIBES.

A
- Capsule univalve . . . . B
- Capsule quadrivalve; involucre polyphyllous or wanting . . . . D

B
- Capsule irregularly dehiscing. Tribe I. CODONIEÆ.
- Capsule quadridentate C

C
- Elaters persistent. Tribe. II. LEJEUNIACEÆ.
- Elaters deciduous. Tribe III. MADOTHECEÆ.

D
- Inner involucre erect, free . . . . E
- Inner involucre erect, adherent to the outer. Tribe XI. MESOPHYLLEÆ.
- Inner involucre pendulous, affixed by the mouth. Tribe IX. SACCOGYNEÆ.
- Inner involucre wanting. Tribe X. ACOLEÆ.

E
- Outer involucre wanting. Tribe VIII. TRICHOLEÆ.
- Outer involucre polyphyllous . . . . F

F
- Elaters persistent. Tribe VI. JUBULEÆ.
- Elaters deciduous . . . . G

G
- Inner involucre compressed. Tribe V. RADULEÆ.
- Inner involucre terete, dentate. Tribe IV. JUNGERMANIEÆ.
- Inner involucre terete, fissured. Tribe VII. CHILOSCYPHEÆ.

Tribe I. CODONIEÆ.

Capsule chartaceous. *Fossombronia.*
Capsule coriaceous. *Codonia.*

Tribe II. LEJEUNIACEÆ.

Inner involucre depressed at the apex, caudate. *Colura.*
Inner involucre rotund at the apex, ecaudate. *Lejeunia.*

Tribe III. MADOTHECEÆ.

Inner involucre compressed. *Madotheca.*

Tribe IV. JUBULEÆ.

A
- Involucre 2-leaved. *Jubula.*
- Involucre indefinite .... B

B
- Elaters solitary. *Frullania.*
- Elaters double. *Phragmicoma.*

Tribe V. RADULEÆ.

A
- Involucre indefinite, the leaves bilobed............. B
- Involucre 2-leaved, the leaves simple............... C

B
- Capsule semipellucid, funnel form. *Radula.*
- Capsule coriaceous, decussate. *Scapania.*

C
- Leaves of involucre foliose. *Plagiochila.*
- Leaves of involucre squamiform. *Adelanthus.*

Tribe VI. JUNGERMANIEÆ.

A	Involucre oligophyllous . . . . B
	Involucre polyphyllous . . . . F
B	Leaves of involucre conduplicate. *Diplophyllum.*
	Involucre 2-leaved, the leaves concave, deeply bilobed, dissected ciliate. *Blepharozia.*
	Involucre 2-leaved, the leaves concave, entire. *Pleurozia.*
	Leaves of involucre 2-many-dentate C
	Leaves of involucre undivided, entire. *Aplozia.*
C	Leaves of involucre like those of them. *Gymnocolea.*
	Leaves of involucre and of stem dissimilar . . . . D
D	Mouth of inner involucre cristate. *Lophocolea.*
	Mouth of inner involucre dentate . . . . E
E	Inner involucre semiconnate with calyptra. *Harpanthus.*
	Calyptra free within the inner involucre. *Jungermania.*
F	Leaves of involucre dissected. *Cephalozia.*
	Leaves of involucre articulate-ciliate. *Blepharostoma.*
	Leaves of involucre palmate. *Anthelia.*

Tribe VII. CHILOSCYPHEÆ.

A	Inner involucre shorter than the calyptra. *Chiloscyphus.*
	Inner involucre longer than the calyptra . . . . B
B	Involucre oligophyllous. *Coleochila.*
	Involucre polyphyllous C
C	Leaves of involucre squamiform. *Lepidozia.*
	Leaves of involucre undivided, serrulate. *Pleuroschisma.*
	Leaves of involucre bilobed. *Odontoschisma.*

Tribe VIII. TRICHOLEÆ.

Inner involucre rough. *Tricholea.*
Inner involucre smooth. *Gymnoscyphus.*

Tribe IX. SACCOGYNEÆ.

A { Capsule spirally twisted .... B
  { Capsule regularly valved C

B { Mouth of inner involucre fissured. *Calypogeia.*
  { Mouth of inner involucre irregular. *Cincinnulus.*

C { Inner involucre terminal, laterally pedunculate. *Gymnanthe.*
  { Inner involucre lateral, sessile .... D

D { Inner involucre not barbed at its insertion. *Saccogyna.*
  { Inner involucre barbed at its insertion. *Geocalyx.*

Tribe X. ACOLEÆ.

A { Calyptra exserted. *Muiopsis.*
  { Calyptra included in the involucre................. B

B { Leaves of involucre free. *Acolea.*
  { Leaves of involucre connate. *Schisma.*

Tribe XI. MESOPHYLLEÆ.

A { Involucre imbricate. *Mesophylla.*
  { Involucre in a circle.............................. B

B { Inner involucre exserted. *Southbya.*
  { Inner involucre included........................... C

C { Leaves of involucre opposite. *Alicularia.*
  { Leaves of involucre whorled. *Marsupella.*

INDEX OF SPECIES.

(*Synonyms in Italics.*)

ARTICLE II. *Description of New Illinois Fishes.* By S. A. FORBES.

LEPOMIS GARMANI, n. sp.

A sunfish of the Xenotis group, of average proportions, rather thin in front, the dorsal outline before the fin well arched, with a decided depression at the nape. Length 4 inches, depth 2.25 in length. Color dark, with a purplish tint; sides striped with rows of bronze blotches, one to each scale, about seven rows below the lateral line. Sides of the head in alcoholic specimens with an appearance of irregular lines. Opercular flap large, about two-thirds the length of the eye, bordered above and below, but not posteriorly, with pale. Head 2.75 to 2.9 in length; nose 3.9 to 4.25; interorbital space slightly greater than length of eye,—3.4 to 3.75 in head. Mouth normal, moderate; rudimentary maxillary bone minute; upper jaw below the middle of the pupil; maxillary 2.85 to 3.1 in head, scarcely reaching the front of the pupil; lower jaw 2 to 2.4; teeth on vomer, not on palatines. Eye large, circular, 3.6 to 4. Cheeks with five rows of large scales; opercles with about six longitudinal rows. Gill rakers very short and few — eight on the lower part of the arch, their length about equal to the diameter of the arch. Dorsal fin of moderate height, — X — 10 to 11, the longest spine 2 to 2.3 in head; length of spinous dorsal 2.9 to 3.25 in body; of the soft dorsal 4.8 to 6.3. Anal III — 8 to 10, its height 4.7 to 5.7 in body, its length 4.2 to 5. Pectoral rather long, reaching anal; ventrals surpassing the vent. Lateral line high-arched, 34 to 41, longitudinal rows 5 to 6 and 13 to 15; 17 to 20 scales before dorsal.

This well-marked little sunfish has been obtained by us only in the Wabash Valley, from Little Fox River at Phillipstown, and from the Wabash River and Drew pond at Carmi.

Described from 15 specimens.

OXYGENEUM gen. nov.

Body long, subcylindrical, a little compressed, dorsal behind ventrals, rudimentary caudal rays not unusually developed. Lateral line complete or nearly so; breast scaly; lower jaw thin, with a sharp, hard edge; upper jaw protractile, with a fleshy covering; no pseudo-branchia; pharyngeal teeth 5—5, with grinding surface. Peritoneum black, intestine long, twice or more the length of head and body.

This genus seems most nearly allied to Acrochilus, from which it differs especially in the absence of a horny plate upon the upper jaw.

OXYGENEUM PULVERULENTUM, n. s.

In general form this species resembles a Moxostoma, having the subcylindrical, slightly compressed body, deep caudal peduncle, and posterior position of the dorsal of that genus, but with a small conical head and large, terminal, oblique mouth. A single specimen obtained is 2.5 inches long, the depth 5 in length, caudal peduncle 4.2. The color in alcohol is light, slightly silvery on sides and belly, brightly so upon cheeks and opercles. Back and upper part of sides finely lined with brown or black, owing to the presence of a small brown spot upon the middle of the front of each scale. The scales on back and sides are finely and uniformly specked with black over all their exposed surfaces, these specks being arranged in concentric rows on each scale. They are more conspicuous upon the lower part of the sides than above, and extend forward upon the upper part of the opercle and the side of the head, and even dot the iris of the eye. The head is pointed, but slightly convex above, scarcely curved from the occiput to the nostrils. It is contained 4.15 times in the length of the fish, and its depth 1.35 times in its length. The nose is rather long, 3.13 times in head, slightly decurved, interorbital space 3.12. The mouth is of moderate size, terminal, oblique, contained 2.7 times in length of head, the lower jaw a little the shorter, thin and somewhat extended around the margin. The upper lip is above the center of the eye; the upper jaw extends to the posterior border of the first nostril, and is contained 3.4 times in head. Pharyngeal teeth 5—5, the three anterior with grinding surface. The gill-rakers of the anterior

gill are rather slender, about .2 the length of the gill filaments. The head and body are contained 2.4 times in the length of the intestine. The eye is circular, of moderate size, 4.1 in head; the branchiostegal rays are broadly united to the isthmus. Dorsal I—8, unusually high, its longest ray contained 4.5 times in head and body, the length of the fin 9.1. The anal is also high, I—7, its height 5.5 in length, its length 9.75. The caudal is long, not very deeply forked; the pectorals and ventrals are of moderate size, the latter reaching the vent, the former 5.4 in length of fish, not attaining the ventrals. The scales are very small and uniform, 63 in the lateral line, with 20 longitudinal rows, and 31 scales before dorsal.

This species is represented by a single specimen obtained from the Illinois River at Peoria in 1878.

NOTROPIS PHENACOBIUS, n. s.

This fish unites with a strong general resemblance to Phenacobius the characters of Notropis. The body of the adult is short and deep, the head square, the nose long, and the eye unusually large. Length 2.5 in., depth 3.5 to 4; caudal peduncle 4 to 4.75. Color in alcohol indefinite; sides somewhat silvery, scales along and above the lateral line slightly specked with black. The head is quadrate in transverse section, flat above, 3.75 to 4; nose decurved, 3.4 to 3.5; interorbital space 2.9 to 3.1. The mouth is inferior, horizontal, rather small, lips fleshy, not lobed, lower jaw much the shorter, 2.75 to 3.1 in head, upper lip opposite the lower margin of the pupil, upper jaw to posterior margin of nostrils, 3.33 to 3.9 in head. Teeth 4—4. Intestine about equal to head and body, .97 to 1.17. Eye very large, circular, placed high up, 3.4 to 3.5 in head. Branchiostegals free from isthmus. Dorsal I—8, decidedly before ventrals, its length 7 to 8 in body; anal low, I—8; paired fins rather broad and short; ventrals not reaching vent, and pectorals falling far short of ventrals, the former 6.25 to 6.4 in head and body. The scales are thin, large, crowded anteriorly upon the sides, breast wholly naked in all the specimens seen. Lateral line 35 to 36, longitudinal rows 7 to 9, 13 to 14 before dorsal.

Described from 10 specimens, the only ones seen, all taken at Peoria.

Notropis macrolepidotus, n. s.

This fish, represented by a single specimen in our collections from Illinois, closely resembles *Notropis atripes*, from which it differs especially in the larger scales, and in the entire absence of any blotch at the front of the base of the dorsal fin. It is elliptical in outline, strongly compressed, its greatest thickness being less than half its depth, the back making a uniform curve from the front of the dorsal to the nostrils. Length 2.1 inches, depth 4.2 in length, caudal peduncle 4.6. Color in alcohol plain, the sides somewhat silvery, the opercles brightly so; no dark vertebral line, but the scales upon the back and upon the upper part of the sides thickly sprinkled with rather large circular black specks; fins all plain; upper surface of the head a little dusky, and thickly sprinkled with black. The head is a compressed cone, 4.5 in length, upper surface convex; snout regularly decurved, 3.5 in head; mouth rather large, terminal, oblique; upper lip opposite the middle of the pupil; maxillary to posterior margin of nostril; upper jaw 3.15 in head, lower not projecting, 2.6 in head; teeth 4, 2 — 2, 4; eye large, circular, 3.75 in head; dorsal fin I — 8, about 4 scales behind the ventrals; anal 11; scale formula 6 — 40 — 3, 19 before dorsal.

Notropis anogenus, n. s.

This is a small, insignificant species, extremely similar to *Cliola heterodon* with perfect lateral line, but clearly distinguishable from it in every case which I have observed, by its peculiar mouth, very small and extremely oblique, the lower jaw standing at an angle of no more than 40 degrees with the vertical. Length, 1.5 in., depth 4.33 to 4.5. Color dark above, yellowish beneath, with a very distinct black lateral band extending from a small black spot at base of caudal along sides to eye and around the nose. Within this band, a small black blotch about each pore in the lateral line. No vertical bar below eye. Back very dark, sometimes nearly black, the scales being thickly specked with black on their lower exposed surface, but only narrowly edged with dusky for one or two rows of scales above the lateral band. Edge of lower jaw also specked with black; fins all dusky. Head dark above, white

beneath, with the opercles silvery. The sides of the fish are also slightly silvery. Head small, 4.25 to 4.5 in length; nose short and blunt, 4.5 to 4.75 in head; interorbital space 2.6 to 2.9; mouth very small, terminal, extremely oblique, almost vertical, lower jaw included, its posterior extremity scarcely reaching the eye, 3.2 to 3.4 in head; upper lip above the upper margin of the pupil; maxillary scarcely attaining the nostril, 4.5 to 5.1 in head. Teeth 4-4, with grinding surface, sometimes plain, sometimes crenate, more or less hooked at tip. Eye large, 3.1 to 3.33 in head; iris dark above, silvery beneath. Dorsal I — 8, about one scale behind the ventrals, very oblique on terminal margin, the posterior rays being less than half the length of the anterior, height 4.5 to 4.66 in length; anal I— 7, height 6.33 in length, pectorals and ventrals moderate, the latter attaining the vent, very nearly as long as the pectorals, 6 to 6.75 in length. Lateral line straight, complete, 34 to 37, longitudinal rows 8 to 11, 13 or 14 before dorsal.

Described from 24 specimens, all collected from Fox River at McHenry.

Parasitic Fungi of Illinois.

PART I.—UREDINEÆ.

By T. J. Burrill, Ph. D.

PROFESSOR OF BOTANY, UNIVERSITY OF ILLINOIS.

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ARTICLE III.—*Parasitic Fungi of Illinois.* PART I. BY T. J. BURRILL, Professor of Botany, Illinois Industrial University.

INTRODUCTION

MOST of the plants herein described were collected in Illinois during 1881 and 1882, by Mr. A. B. Seymour, who was employed for the purpose by the Illinois State Laboratory of Natural History. The entire collection consists of three thousand seven hundred and eighty-four numbers, many of which are of course duplicates, or are different stages of the same species, leaving, however, a very large number of distinct specific forms—much larger than is usually supposed to exist in our flora.

The determinations have been made at the Illinois Industrial University by myself, efficiently aided by Mr. Seymour. For this work, besides the facilities offered by the library and herbarium of the University, the State Laboratory of Natural History furnished many books and specimens. Among the latter are the following sets of exsiccata: DeThümen's Mycotheca Universalis, Ellis' North American Fungi, Ravenel's Fungi Caroliniani and Fungi Americani.

The entire work has been stimulated and aided in every possible way by Professor S. A. Forbes, as director of the State Laboratory, and as an earnest and efficient worker in our rich fields of scientific and practical biology. Acknowledgements are also gratefully made for assistance in various ways, especially in the determination of specimens submitted to their inspection, to Prof. W. G. Farlow, and the State Botanist of New York, Chas. H. Peck; to F. S. Earle, J. C. Arthur, and C. A. Hart, for the contribution of specimens found by them in Illinois, and to Professor Wm. Trelease, J. B. Ellis, and others for several favors.

It needs no argument to show the practical value of the studies undertaken upon these minute — probably degraded — members of the vegetable world, for they subsist on living plants of the higher orders, upon which our domestic animals and ourselves depend for the means and materials of physical existence. It is not, indeed, usually known or suspected what proportion of our crops and useful vegetation is destroyed by the microscopic growths which live as parasites or saprophytes upon them; but when we come to understand that in very great measure the things called "blights," "mildews," "rusts," "smuts," "rots," "ferments," etc., are really due to the despoliations of these same microscopic but multitudinous forms of fungi, some appreciation can be gained by anyone, even with a moment's thought, of the immense aggregate loss that occurs. Perhaps, in one sense, it is well that cultivators do not fully realize the number and variety of parasitic growths which await the development of their valuable plants, and which are liable so badly to injure the latter, and so seriously to affect the receipts for the expended labor. Surely in many cases there would be sufficient ground for discouragement and hesitation to venture in opposition to such an array of dangerous enemies, against whose insiduous and covert attacks fighting seems futile.

But knowledge of the existence of such things cannot make that existence more hazardous, nor the results more distressing; while here, as in the other battles of life, to be forewarned is to be forearmed. Knowledge is power, and as much so in this case as in any other; if the latter is still wanting, it is only because the former has not been attained. Is it attainable? There are difficulties in the way. The objects are very minute; we cannot see them by the unaided eye as individuals, we cannot thus watch their modes of dissemination, germination, growth and development, we only see them, if at all, in the mass, and know of their presence by their results. They have singular, and to the students of other forms of life, unfamiliar physiological powers and properties; they assume peculiar disguises, and pass through unlooked-for stages of development, of which the connecting links are hard to make out; they lie dormant now, and again become wondrously quickened and enormously multiplied under circumstances not readily

traced. But little by little qualified observers have acquainted themselves with their existence as true species, veritable and distinct plants, and little by little have learned something of the mysteries of their life histories. Sometimes the advance in knowledge is gained by casual and lucky observations; but mostly by painstaking, systematic research, aided by all the appliances of the equipped laboratory and the fruitful skill of trained powers of manipulation and acute perception. A step gained is not only so much secured, but renders more possible other or further advance. The more becomes known, the easier progress is made, since that already acquired points the way towards new achievements. The beginning has been made, though this can scarcely be said to have been true until within very recent times. The men are now living and working who have made known nearly all the ascertained facts of physiological processes and results in these parasitic fungi. The germination of fungous spores was not observed until within the present century.

During the last part of the first half of this century learned discussions arose upon the specific distinction between the parasite and the host, and esteemed botanists held the view, that what was taken for the former was but a diseased condition of the latter—the rust of wheat, for example, was only the degraded cell-tissues of the wheat itself. Such difference of opinion, however, no longer exists among those who have possession of the information now acquired. The tissues of higher plants do not change by any processes of degradation or transformation into the things called fungi, neither do the latter originate in any other manner than as descendants of preëxisting parent forms through as rigid specific lines as can be traced among any animals or plants. It is known, too, that however much the fungus is found within the tissues of the host plant, it began its growth outside of the latter, and gained introduction only by forcible entrance. Spores are never taken up by absorption and carried by the aqueous currents from part to part of the plant. The fungus passes through the tissues very much as roots pass through soil, sometimes apparently without in any degree successful opposition.

sometimes nearly or quite baffled in the struggle by the mechanical and physiological resistances of the host plant.

I repeat, we now know that the numerous "rusts," "smuts," etc., found on the various kinds of vegetation, are themselves true plants, and that as such they are limited in their development like other organic species by certain conditions and surroundings. Some of these limitations are well known, others are yet to be ascertained. At present there is, except in a few cases, not enough of trustworthy information to enable us to suggest practical remedies or means of effectually destroying the injurious fungi which so reduce the products of our fields, fruit plantations, and gardens; which so disfigure our ornamental trees and defoliate our forests. But the difficulty exists not so much in the unconquerable nature of the enemies, as in the want of fuller attainable knowledge concerning them and their ways. There is reason to predict that the time will come when the mastery of man will prevail in this as in so many triumphs of the past by the application of power made available through persevering research and educated perception.

In some cases, however, we now know practical methods of exterminating the parasites, and in other cases of preventing their ravages by various processes of cultivation, selection or application. Usually these methods are quite beyond haphazard discovery, and often very remote from previous conception. For example: the leaves of apple trees are sometimes destroyed by a parasitic fungus which shows itself in prominent, scurfy bunches occuring here and there on the under side of the affected leaves, while upon the upper surface of the same spots the thickened area has a yellow or sometimes a crimson color. The leaf is distorted in shape, shows very evident signs of injury, and finally becomes ragged and withered. When a large number of the leaves of a tree are thus diseased the latter perceptibly suffers, and though seldom killed outright, after an unequal struggle for some years is rendered entirely worthless, and may as well be removed by the axe in the hands of the disappointed proprietor. Now the injury arises from a parasitic fungus described below (*Gymnosporium macropus*), which, in an alternation of development, takes a very different form on

the common red cedar, constituting the so-called "cedar balls," of orange color, especially noticeable after a rain in the month of May. The relation of these two forms of the fungus was not suspected until carefully established by Oersted, a botanist giving special attention to such matters, and well qualified for such observations and experiments. The fact having been ascertained, a thoroughly practical remedy consists in clearing away the worthless red cedars, or, in case of a few of these trees, which for any reason are wished to be saved, picking off and burning the "cedar balls." In this case the spores produced on the apple leaves cannot germinate and grow on the apple, but must reach, by wind currents or otherwise, the cedar leaves, where alone one essential stage of development takes place. From the cedar the spores must again be carried to the apple tree, or allied host, thus alternating back and forth as a necessary requirement of continued existence.

This is by no means a solitary example of known alternations which render possible the agency of man in preventing plant diseases caused by these pernicious parasites; but to gain the fullest possible mastery we still need much investigation and experiment by those most competent to conduct them. It has long been known that the rust of wheat (*Puccinia graminis*) has an alternate form on the barberry bush, but since the rust occurs in vast regions of our country where no barberry exists, we know that this plant is not positively essential to the continuous development of the rust. It now seems probable that the barberry stage is a reality, and perhaps in some way beneficial to the Puccinia (rust), but not essential. It still remains, however, to be ascertained whether or not there is some other common plant usually found in or near the wheat fields, which takes the place of the barberry, and thus permits the continued growth of the rust.

What might be the practical value of investigation in this direction? There are annually produced in Illinois about 50,000,000 bushels of wheat. The destruction of one-hundredth part of the crop by this fungus probably falls, as an estimate, far within the actual limits of loss as an annual average. This represents 500,000 bushels, which, at seventy-five cents per bushel, is $375,000. If it could be demonstrated that the eradi-

cation of some worthless or otherwise noxious weed would at the same time dispose of the rust fungus, what a step of progress would be made! It cannot be said, from what we now know, that this is probable, but it certainly is possible, and not this only. In such cases no estimates can be ventured as to the value, measured in dollars and cents, of the smallest contribution to positive knowledge. Years of patient and able research may pass without reward, or a day's labor may beneficially affect the world. The field is very large and the soil very rich; but the cultivators have little more than begun their labors, and those competent for the task are still few. No great pecuniary inducements urge them forward. There are no patents to be had on discoveries they may make. The products of their labors, however rich, are not to be appropriated by themselves, but the gathered harvests must equally be divided among all men. Science may be enthusiastically pursued for its own sake, and mankind owe much to labors thus pursued; but it is certainly proper that the State should provide the means of equipment and livelihood for those able and willing to devote their energies to such investigations and experiments.

Illinois is one of the few States of the Union which have provided by legislative action for an officer whose duty it is to investigate and report upon insect depredations, and is alone in the establishment of a well equipped and well appointed laboratory of natural history, while the maintenance of the State University, with its departments of science and practical art, shows the high official appreciation of studies and investigations of this kind, and the intelligent views of those shaping and directing the affairs of the State pertaining to our natural resources and the value of natural science. The beginning thus made gives much hope for the future. It is not hazardous to predict increased interest as the work goes on, not only on the part of those conducting the investigations, but among the people at large, many of whom care little or nothing for the methods and processes by which results are reached, but quickly appreciate the practical value of the results themselves when wrought out.

Nothing has so far been done by the United States' authorities for the study of the diseases of plants, though recently

much attention has been given to contagious diseases of animals. The importance of scientific investigations in this latter direction cannot be overestimated, yet it would not be difficult to show that every argument in support of these is applicable also to encouragement upon the study of the diseases of plants. In fact, it has now come to be generally admitted that these very maladies of animals are directly due to various species of the same classes of low vegetable organisms which afflict, as parasites, the valuable plants and crops. In some instances the very same species of fungi prey upon plants or plant-products and living animals. The common moulds are fungous growths, and mouldy grains and other articles of vegetable foods are commonly believed to be injurious to man and animals. Some contagious diseases of man have been proved to be due to organisms normally living on vegetable substances, and there is much reason to suppose that all the pathogenic bacteria, and their allies, are or were primarily simply decomposing agents of dead substances. Certainly the nature of the contagious diseases of animals cannot be fully known without the closest investigations of the life of the disease organisms outside of the animal body. The studies of fermentations and putrefactions have already lead to most important results in pathology, and it is confidently believed that there is much more to be gained in the same way for the advancement of knowledge in regard to disease and injury, not of animals only, but of plants as well: while a proper study of the diseases of plants must help to a better understanding of the serious maladies of man and the domestic animals.

The nomenclature adopted in this paper has been the result of considerable inquiry and an earnest endeavor to conform to the latest opinions of the best authorities, as well as to most nearly fulfill the requisites of this branch of science. Unfortunately, in numerous cases there are many synonyms, and as names were given to species before any natural classification could possibly be made, and as the life history was in the earlier times usually unknown, different writers assigned the same species to widely different positions in their systems of arrangement. The descriptions by the older authors are mostly meager, and entirely devoid of accurate microscopic character-

istics on which so much reliance is now placed, so that in the absence of type specimens it is difficult or impossible to ascertain to what species their names should be applied. Besides this, what we now know to be different forms of "fruit" of the same species, were formerly regarded as wholly distinct plants belonging to widely separated genera; as each of these forms received a name it now becomes necessary to choose one from two, three, or even more, to designate the species and reduce the others to synonyms. In the case of the Uredineæ there are in numerous species four spore-forms, now known as "teleutospores," "uredospores," "æcidiospores," and "spermatia," from which one must be selected as the mature or final "fruit," and its name taken for the species as a whole. But as no process of fertilization has been discovered for any of these spore productions, there is a difference of opinion among investigators as to which ought to be considered this mature or final form. Sachs, whose judgment must be highly respected, adopts the æcidium stage as that most probably the result of some kind of fertilization, while others, equally competent, believe the teleutospores — as the name indicates — are the final and, if any, the fertilized bodies. Sachs, therefore, inclines to call the common rust of wheat *Æcidium graminis*, instead of *Puccinia graminis*, the name used by all authorities up to this time. Winter, in his recent revision of Rabenhorst's *Pilze* (Fungi), attempts to apply rigorously the law of priority of names to whatever form of the species the first name was given, and most naturalists making a specialty of any other department of nature would doubtless commend his endeavor. But there are very serious difficulties in the way. While we may accept as proved that certain Æcidia are genetic forms of known Pucciniæ, in the great number of cases such relation is simply *supposed* to exist. Shall we revise our nomenclature on the basis of a supposition? In the writings of early mycologists the descriptive characteristics following a name are often equally applicable to several species as we now know them. In the absence of herbarium types, shall we guess at the plant held in hand when the description was drawn up? Not unfrequently the oldest name is given to what was deemed a variety, and later another name by another or the same author is adopted

for the same plant as a species. Shall we now write the earliest varietal name as specific, and quote the first botanist as authority? The question is not whether the second writer should have adopted the first name: it is now a question of choice between two names already in literature.

The authority after a binomial appellation is clearly that of the one who associates the generic and specific parts of the name, and applies it, thus constituted, to the designated plant. For phænogams there seems to be little need of preserving with the name any further item of bibliography. The change of genera is not so frequent as to cause serious confusion, and the descriptions are ordinarily full and unmistakable. Mycologists, however, find it important to quote the name of the original authority for the specific name, agreeing in this with the custom among zoölogical writers, especially with those who devote themselves to the lower and less known orders of animals. A very considerable number of the names of fungi must thus be accompanied with two authorities, that for the original specific name occurring first in parenthesis, and that for the binomial whole afterward. It is true this decidedly increases the difficulty of writing and of memorizing, but the benefits more than counterbalance the drawbacks. Certainly it will not answer to quote alone that which, as above, is put in parenthesis, even though by the use of the parenthesis change of genus is indicated. The parenthetical reference is dropped by students of phænogams, and we should, as mycologists, prefer this to the practice of some botanists and zoölogists of omitting the authority for the entire name as it exists.

Without further discussion of this often discussed topic, the following may be stated as the basis of nomenclature in this paper.

(1). The use of the oldest specific name known to have been used for the *species* as such. Varietal names by the older authors, not subsequently adopted by those raising the varieties to species, have not been herein perpetuated except in peculiar cases. When the vague descriptions of the early writers give no reasonable certainty of the intended application, priority is not strained to retain the names.

(2). In the Uredineæ the names of the teleutospore and uredospore stages are alone considered in the question of priority. Æcidial names are not recognized, mainly from the uncertainty that exists as to the genetic connection of the forms, as well as from the obscurity of descriptions, and the inferior value of herbarium specimens as types.

(3). The name of the author responsible for the specific appellation has been appended, being inclosed in parenthesis in case the generic association has been changed; and the name of the author of the binomial combination, whether the parts were adopted from others or not, finally follows. In quite a number of cases this author is not known to us, owing to the too prevalent habit of omitting the citation.

The descriptions of species are taken from nature, and as far as possible from typical or average specimens. The measurements given are intended to include the variations which commonly occur in such specimens; but the extreme limits of exceptionally large or small spores are not indicated. In most cases the measurements were made of spores immersed in a solution of potash, so as to obtain the size of the mature but undried specimens. For the study of the surface markings, examinations were made when necessary of spores either dry or wetted with pure water, whichever method was found from experience to produce best the particular effects required. The color given is as closely as possible that of nature rather than an interpretation of the appearance of a few spores in the field of the microscope. It need scarcely be said that the tint is much lighter in the latter case. The best objectives of different makers were used, and for the closer studies a magnifying power of about five hundred diameters was employed.

It has been deemed worth the while to quote the description given by another author; usually, when accessible, the original description of the species in each case. The quoted descriptions are printed in different type, and are followed by a reference, with name, date, and page, of the work from which the extracts are made.

Notes are appended when required; these follow the collector's numbers and designations of localities, and are intended to record any special facts about, or information upon, the

species. It has not been considered wise to try to give a full list of synonyms, yet such references are made in the notes as are needed to justify any departure from common usage in the selection of names. In a few instances changes have been made with much regret, since the current names are well established; but in these cases the law of priority clearly demands the substitutions made. For instance, the rust on the leaves of the common sunflower, and other allied plants, has long been known as *Puccinia helianthi*, Schweinitz. Probably no species of Puccinia is more commonly found or better recognized in the herbaria of our country, and nearly or quite uniformly under the name quoted. But Schweinitz published this name in 1822 (Syn. Fungi Carol. p. 73), seven years after De Candolle had published the description of a species of Puccinia under the name of *P. tanaceti* (Flore Franc. II. p. 222). Now it is found that no specific difference can be maintained between these, and therefore the latter name must be adopted for the collections made in America as well as for those of Europe.

T. J. BURRILL.

ILLINOIS INDUSTRIAL UNIVERSITY,
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Descriptive Catalog

UREDINEÆ, De Bary.

Parasitic plants of minute size, growing in the tissues of living phænogams, or, in a few cases, of living vascular cryptogams; mycelium articulated, variously branched, penetrating or growing between the cells of the host; spores usually produced by constriction, singly or in chains, from the ends of fertile hyphæ (mycelium branches), formed beneath, rarely within the cells of, the epidermis, which is ultimately ruptured; spore or fruit forms of different kinds, viz: æcidium and spermogonium, uredo and teleutoforms.

The Uredineæ are parasites, and affect a very large number of the species of the higher plants, being found most often upon the leaves, but also in some instances upon the stems and parts of the flower or fruit. The roots alone are free from their intrusion, and these probably because protected by the soil.

The most remarkable thing concerning the Uredineæ is their peculiar alternations of fruit forms—"dimorphism," "polymorphism," or "pleomorphism." The teleutospores, the last in the series, and usually the only ones surviving over winter, upon germination emit a slender tube called the promycelium. This is never very long or complex in structure, but may be with or without septa, simple or branched. It produces at once, on minute stalks (sterigmata), one to several thin-walled, more or less globular bodies, rich in protoplasm, and known as sporidia. These in turn soon germinate by sending out a little tube, which, upon the proper host, penetrates the tissues and forms the mycelium or vegetative structure of the parasitic plant. Then follow in order, as products of the mycelium, the fruit forms known as spermogonium, æcidium, uredo, and teleutospore. The two first are usually produced simul-

taneously, or nearly so, on the infected area of the host, but most often on the opposite sides, if of a leaf. In some cases the other fruit forms subsequently develop in the order named upon the same mycelium, but in others only on a new mycelium produced from the germination of the æcidium spores, and either on the same or different hosts, according to the habit of the species. These alternations may be best understood by consulting what is said under the genus *Puccinia*.

But this full series of forms is not found in all the species. Indeed, there are comparatively few which are really known to have in their regular course of development all the stages as necessary requirements of growth. In a few instances it is known that species, which under some circumstances have this or that form produced, may, under other circumstances, perpetuate themselves though one or more forms are omitted. In very many cases the genetic connection of different fruit forms has not been satisfactorily made out; but contributions to knowledge of this kind are from time to time gained, and through the interest now taken in the matter more rapid advance may be expected in the future. For this purpose artificial cultures, with the most painstaking care to avoid mistakes, are required. The spores must be placed on the proper host under proper conditions, and the development carefully followed through the season. It is believed that in some specie only teleutospores are produced, in others only uredo and teleutoforms, and these from the same mycelium; in still others only æcidium and teleutoforms. The office of the spermogonia has not been conclusively ascertained. Cornu, of France has seen the spermatia from them germinate in certain nutritive fluids, but not in water, and he has supposed they may under certain conditions reproduce the plants like other spores. Many have attributed to them sexual functions, but the proof is unsatisfactory. It has been observed that some spermogonia are fragrant, and insects are known to visit them, hence the inference that the special office may be for dissemination.

In most cases the mycelium of these plants wanders little from the point of penetration of the host tissues — in this strikingly differing from the usual growth of the species of *Ustilagineæ* and some other groups of fungus parasites. In

leaves the vegetative threads are seldom found at a greater lateral than vertical distance, the latter limited by the thickness of the leaf; yet the whole tissue may be permeated by the mycelium of different, perhaps very numerous, spores.

In the preparation for the formation of spores, mycelium-threads become densely aggregated into a parenchyma-like tissue in a little area just beneath the epidermis, and from the upper surface of this minute cushion the spores are produced by the enlargement and modification of the end of a thread, either singly, or by the formation of septa, from two to several — in the latter case so as usually to form a single vertical row from each fertile filament. The clusters of spores (sori), usually very densely packed, are naked, or surrounded by peculiar sterile cells (paraphyses), produced from the mycelium or entirely inclosed in a membranous envelope (pseudoperidium), originating from the same source. By the growth of the fungus the epidermis of the host is pushed up and finally ruptured, so that the spores, mostly just at maturity, are exposed to the air, in the currents of which they are light enough to be carried as fine dust.

The species of *Uredineæ* are limited to particular host species, mostly to one, or at farthest to the species of one genus or closely allied genera. None are certainly known to grow upon plants of different natural orders, except in the alternation of fruit forms. In the latter case the teleutospores produced upon grasses or sedges give origin, in some species, to æcidia on the leaves of certain exogens. In fact, it seems to be most common that when the æcidium is not grown on the same host with the uredo and teleutoforms, very wide divergence in this respect is made. Wheat and the barberry bush, oats and the buckthorn, red cedars and apple trees, are three examples of this remarkable peculiarity, the teleutoform in each case being found on the first named, the æcidium on the second.

Following the descriptions of species in this paper, references are given for each species to the host plants, the localities by counties (of Illinois), and the date of collection. The numbers in Arabic figures are those of the herbarium specimens, corresponding with those of the collector's notes; the

Roman numerals often following the above indicate the stage of development of the fungus; viz. I., æcidium; II., uredo; III., teleutospore.

Key to the Genera of Uredineæ.

I. Spores at maturity forming a more or less powdery mass.

- A. Spores with a permanent pedicel, mostly smooth and dark brown.
  - 1. Spores one-celled .... Uromyces.
  - 2. Spores two-celled, septum horizontal ... Puccinia.
  - 3. Spores three-celled, septa in different planes. Triphragmium.
  - 4. Spores three or more celled, septa horizontal. Phragmidium.
  - 5. Spores many-celled, septa variously placed. Ravenelia.
- B. Spores with deciduous pedicels or none, one-celled, mostly roughened with minute projections, usually yellow or reddish-brown.
  - 1. Sorus with a peridium, spores produced in vertical chains, without pedicels.
    - a. Peridium cup-shaped, rim-border mostly toothed or lobed and recurved .... Æcidium.
    - b. Peridium hemispherical or bowl shaped, deeply immersed .... Endophyllum.
    - c. Peridium elongated, usually cylindrical or conical, soon split-fringed above .... Rœstelia.
    - d. Peridium various, bursting irregularly, white, on Coniferæ .... Peridermium.
  - 2. Sorus without peridium.
    - a. Spores produced in vertical chains, without pedicels, usually accompanied with spermogonia. Cæoma.
    - b. Spores produced on pedicels (deciduous), not accompanied with spermogonia .... Uredo.

II. Spores at maturity embedded in gelatine, two-celled, septum horizontal, pedicel long .... Gymnosporangium.

III. Spores at maturity in a dense, waxy or crust-like stratum, not separating from each other.

A. Spores one-celled, less commonly several-celled, and then the septa almost never horizontal, mostly dull reddish brown.

1. Spores one-celled, oblong, united in an erect (often curved) cylindrical column ...... CRONARTIUM.

2. Spores one or more celled, septa, when present, mostly vertical or oblique, united in a flat or convex stratum .... MELAMPSORA.

B. Spores several-celled, septa horizontal, mostly reddish-orange.

1. Spore cells short (not longer than wide), united in a flat waxy mass, cell rows simple.
COLEOSPORIUM.

2. Spore cells oblong or cylindrical, in simple or branched vertical rows, not waxy . CHRYSOMYXA.

UROMYCES LINK.

Teleutospores one-celled, brown, produced singly on permanent pedicels, usually longer than the spore, arising from a compact layer of small irregularly shaped cells beneath the epidermis, which is finally ruptured, exposing the more or less powdery mass.

Like most of the genera of *Uredineæ* the biological development of the *Uromyces* is very complex, and in the different species variously diversified. All the spore-forms exist on the same or different hosts, or any one, or even all but one (the teleutospore) may be wanting. In most cases the teleutospore germinates only after a considerable period of rest, but in a few species exceptions to this occur, and there are also exceptions in regard to the permanence of the pedicels. When the spores readily fall from the stalks, they can be distinguished from stalked uredospores by the different appearance — usually smooth instead of being roughened with minute and mostly sharp-pointed prominences — or by the tardy germination when ripe. Puzzling forms occur, in which some of the

teleutospores are divided like a *Puccinia;* but because a few such spores are found among many of single cells, the species should not be transferred to the latter genus unless there is good reason to suppose that the single celled spores are the abnormal ones.

In England the æcidial forms of the greater proportion of the *Uromycetes* are supposed to be known; but in our own flora almost nothing has been demonstrated. In the following those species which have their æcidia on the same host are thus indicated in the notes.

U. hyperici, (Schw.) Curt.

I. Hypophyllous; spots small, scattered, purplish; æcidia minute, about six (one to nine) in a cluster, semi-immersed; short; spores orange.

II., III. Hypogenous; spots small, light cinnamon or purple; sori numerous, scattered. Uredoforms and teleutoforms often in the same sorus, the latter succeeding the former. II. Sori small, roundish, long covered by the epidermis, then surrounded by its ruptured remains; spores light yellow, globose to elliptical-oblong, minutely echinulate, 16–19 by 19–27 μ. III. Sori becoming larger, angular and conspicuous, ruptured epidermis prominent; spores elliptical or oblong, tapering to the base, strongly thickened at the obtuse or rounded apex; 12 by 21–27 μ; pedicel tinted, 1–2 times the length of the spore.

Spots on the stem pilose-strigose, purple; sori scattered, acuminate-ovate, bullate, elevated, surrounded by the ruptured epidermis.—Schw. N. Am. Fungi, No. 2843, p. 292.

On *Hypericum mutilum:* Union, Oct. 25, 2008, I., III.; *Elodes virginica:* Cook, Sept. 6, 1447, II., III.; Sept. 8, 1462, II., III.; LaSalle, Sept. 28, 6218.

Cooke (Proceedings Portland Soc. Nat. Hist., Vol. 1, part II., p. 184) described, under the name *Uromyces triquetra*, a species on *Hypericum*, and questioned its identity with the plant described by Schweinitz. Peck (25th Rep. p. 74) adopts the name given by Cooke, but Farlow (Ellis N. A. Fungi, 281) uses, for what seems to be the same, Schweinitz's name. In

the exsiccated specimen of Ellis, and the Illinois collections, sori also occur on the stems, in this differing from Cooke's description of *U. triquetra*, and the spores are not commonly angular, certainly not usually three-sided. The above description is drawn from specimens on *Elodes virginica*. On *Hypericum mutilum* the sori occur on both stems and leaves, are smaller and rounded, and the spores are rather smaller and lighter colored.

U. terebinthi, (DC.) Wint.

Amphigenous; spots yellow or yellowish red or none, usually small; sori minute, scattered or crowded, soon naked. II. Spores elliptical, often roundish or oblong, usually obtusely pointed, covered with spiral lines of minute warts or beads, yellowish brown, 25 by 25–40 μ, on a short hyaline deciduous pedicel. III. Spores vertically compressed or globose, with an obtuse cap-like point, verrucose with prominences in short irregular undulating lines, dark brown, about 25 μ long (vertical dimension) and 30 μ wide; pedicel hyaline, stout, permanent, several times as long as the spore.

Uromyces toxicodendri, B. & R. Effused, rufous; spores ovate, obtuse or apiculate, marked with short lines somewhat like the sporidia of *Ascobolus furfuraceus*.—Berk. Grev. vol. III., p. 56.

Pileolaria brevipes, B. & R. Forming little specks on the under side of the leaves; stem short, flexuous; spores at first globose, with three coats, then depressed with a central nucleus. .00114 in. diam.—Berk. Grev. vol. III., p. 56.

On leaves, petioles and stems of *Rhus toxicodendron:* Champaign, June 9, 4928, II.; Adams, June 27, 5319, II., July 6, 5432, II., July 12, 5523, II.; McLean, July 12, 2442, II., July 16, 2437, II., III., 2438, II., III., July 20, 5605, II., 5606, II., July 22, 2439, II., 2440, II., III., Aug. 1, 2442, II., III., Aug. 4, 2443, II., III., Sept. 6, 5657, II., III., Oct. 6, 1811; Piatt, Aug. 15, 1066, II., III.; McHenry, Aug. 24, 1266, II., III.; La Salle, Sept. 14, 1534, II., III.; Stephenson, Sept. 14, 5883; Ogle, Sept. 25, 6167; Jersey, Oct. 14, 6317; Union, Oct. 25, 2019.

This is often referred to the genus *Pileolaria*, Cast.; but mycologists are pretty well agreed (Léveillé, Tulasne, Winter,

Farlow, and others) that the plant is not generically distinct from *Uromyces*. This being admitted, a further question comes upon the specific distinction between the American plant on *Rhus* and the European one on *Pistacea*, an allied genus. Ours was published in Ravenel's Fungi Car. Sup. (1855), under the names of *Uredo toxicodendri*, Berk. & Rav., for the uredoform, and *Pileolaria brevipes*, Berk. & Rav., for the teleutoform, and the latter name has been commonly used, though the significance of the specific appellation is unintelligible or incorrect, for the pedicels are conspicuously long. Upon comparing specimens and descriptions of European and American plants, it does not appear that the latter can be maintained as a distinct species, hence the name previously given to the former has here been adopted (*Uredo terebinthi*, D. C. Flore Franc. [1815], VI, p. 71). The teleutospores are not at all different, but in the poor specimens at hand of the European uredospores, the spiral arrangement of the prominences cannot be so well made out; however, Schröter (Hedwigia XIV. [1875], p. 170) does not find any difference between them. Doubtless there is none.

It is peculiar that a difference of opinion should exist as to which of the forms is the teleutospore. In these specimens the yellowish fragile-stalked form appears alone in the collections of July, in those of August this is well scattered but present, while the thick-walled long-stalked form may be found in sori still mostly covered by the epidermis, and later (October) only this last is found.

U. hedysari-paniculati, (Schw.) Farlow.

II., III. Spots yellow or none; sori amphigenous, scattered over the whole under surface of the leaf, few above. II. Sori small, yellowish brown, scattered; spores subglobose, echinulate, 18 by 21 μ. III. Sori small, compact, soon diffuse and confluent, brown or blackish; spores acute or oval, obtuse, conspicuously papillate, reddish brown, epispore thick, size 18 by 21 μ; pedicels broad, slightly colored, slightly curved below, twice the length of the spore.

Sori minute, but thickly scattered over the whole leaf, innate with the epidermis. Spores long-pediceled, with the pedicels articulate, pel-

lucid or opaque, ovate, obtuse, not cylindrical, obscurely septate, not articulate, constricted.—Schw. N. Am. Fung., No. 2947, p. 297.

On leaves of *Desmodium paniculatum:* LaSalle, Sept. 17, 1561, II., III.; Union, Oct. 22, 1941, Oct. 24, 1992; Pulaski, Nov. 4, 2254, II., III. *D. cuspidatum:* Henry, Sept. 28, 1729; Union, Oct. 22, 1944, 1948 and 1954, Oct. 24, 1980 and 1990, II., III. *D. Canadense:* JoDaviess, Sept. 15, 5913, Sept. 20, 6015; Jersey, Oct. 13, 6290. *D. rotundifolium:* Jersey, Oct. 14, 6321. *Desmodium sps.:* Union, Oct. 24, 1979 and 1991.

In Schweinitz's Syn. Fung. Car. (No. 503) this species is named *Puccinia Hedysari paniculati*, but in his N. Am. Fungi (p. 297, No. 2947), subsequently published, the name is *Phragmidium Hedysari.* The plant called *Hedysarum paniculatum* by Schweinitz is now transferred to the genus *Desmodium*, with other species upon which the fungus also occurs. In March, 1878 (Hedw. XVII., p. 39), Cooke described the same plant under the name *Uromyces Desmodii;* and Thümen, at the same time (Bull. Torr. Bot. Club, VI, p. 215), also bestowed the latter name upon the species, with a still fuller and better description. Farlow (Ellis N. Am. Fungi, No. 246 [1879]) restored the original specific name, and wrote *Uromyces Hedysari-paniculati* (Schw.).

U. lespedezæ, (Schw.) Peck.

II., III. Hypogenous and often also sparingly epigenous; spots yellowish, very small; sori small, scattered, at first covered by the epidermis, lead-colored, soon exposed, black, surrounded by the ruptured remains of the epidermis. Uredo sori light brown. Both kinds of sori often surrounded by curved paraphyses. II. Spores pale, subglobose, 16–18 by 18–21 μ; epispore rather obscurely echinulate. III. Spores rounded to oblong, with the rounded, obtuse, or pointed apex strongly thickened, frequently forming one third of the length of the spore, blackish brown, smooth, 12–15 by 21–27 μ; pedicel hyaline, rather broad, about 36 μ long. Paraphyses hyaline, of nearly uniform diameter, rounded apex, 6–9 μ broad.

On leaves of *Lespedeza procumbens:* Jackson, Oct. 22, 1952; Union, Oct. 24, 1982. *L. repens:* McLean, July 29, 2349, I., II.; Stephenson, Sept. 14, 5884, Oct. 13, 1860; La

Salle, Sept. 14, 1523, I., II.; Union, Oct. 21, 1910, Oct. 22, 1943, Oct. 26, 2026, Oct. 31, 2148. *L. violacea:* Cook, Sept. 5, 1443; JoDaviess, Sept. 15, 5914; Jersey, Oct. 12, 6264; Union, Oct. 22, 1942, Oct. 31, 2147. *L. hirta:* Union, Oct. 21, 1918, Oct. 22, 1963, Oct. 26, 2025. *L. capitata:* McHenry, Aug. 25, 1293, Aug. 27, 1338; Cook, Sept. 7, 1461; Lee, Sept. 11, 5781; LaSalle, Sept. 17, 1568; JoDaviess, Sept. 20, 6016; Ogle, Sept. 23, 6145.

The so-called "capitata" form is common on most species except *L. violacea*. Paraphyses usually accompany this form, and are mostly absent in the typical one, but many exceptions occur.

Schweinitz (Syn. Fung. Car. [1822] Nos. 497 and 498) describes this species under the names *Puccinia Lespedezæ procumbentis* (497) and *P. Lespedezæ polystachyæ* (498).

U. fabæ, (Pers.) DBy.

II., III. Spots small, black; sori amphigenous, sparse above, scattered, round or oblong, black, surrounded by the prominent remains of the ruptured epidermis. II. Spores in roundish, small and inconspicuous brownish sori, globose or oval, obscurely warty, pale brown, 21–24 by 24–29 μ. III. Spores roundish-oval, obovate, oblong, pyriform or often irregular, epispore smooth, apex strongly thickened, obtuse or rounded, 18–21 by 27–47 μ; pedicels broad, a little longer than the spore.

On leaves of *Lathyrus palustris:* McHenry, Aug. 23, 1238, II., III. *L. venenosus:* McHenry, Aug. 20, 1156; Stephenson, Sept. 13, 5827. *L. ochroleucus:* Lake, Aug. 27, 1343.

Persoon, in 1794 (Roemer's N. Mag. I, p. 93), named a fungus *Uredo Fabæ*, and this is presumably the uredo form of the present species. In 1801 (Syn. Fung. p. 221) he described under the name of *Uredo Viciæ Fabæ* what is no doubt the teleutoform. DeBary (Ann. Sc. Nat. IV. XX. [1863]) wrote *Uromyces Fabæ*.

U. viciæ, *U. viciæ-fabæ*, *U. ervi* and *U. orobi* are synonyms.

U. appendiculata, (Pers.) Lév.

II., III. Spots yellowish and indefinite or none; sori amphigenous, scattered, pulverulent, often confluent. II. Sori

yellowish brown, spores subglobose or oval, echinulate, 18–21 by 21–24 μ. III. Sori blackish purple, elliptical to subrotund, with a prominent obtuse hyaline apiculus, epispore thick, smooth, 18–24 by 27–32 μ; pedicels hyaline, fragile, 1½ to 2 times the length of the spore.

On *Phaseolus vulgaris:* Boone, Sept. 2, 1425, II., III.; Union, Oct. 21, II., III., Oct. 24, 1983, II., III. *P. diversifolius:* Cook, Sept. 5, 1442, Sept. 6, 1448, II., III.; Lee, Sept. 9, 5753, II., III.; LaSalle, Sept. 17, 1562, II., III.; Rock Island, Sept. 24, 1643, II., III.; Union, Oct. 21, 1907, Oct. 24, 1981, Nov. 3, 2189. *P. helvolus:* Union, Oct. 24, 1967, Oct. 25, 1995, Oct. 29, 2112.

In Obs. Myc. I, p. 17, Persoon described *Uredo appendiculata*, and in Syn. Fung. pp. 221–222, repeated it with var. *phaseoli*, and two other varieties. The latter have been referred to other species, leaving the original name for this form; but the name *Uromyces phaseoli* is frequently used.

U. œnotheræ, Burrill.

I. Infected leaves somewhat involute or revolute; peridia irregularly scattered over both surfaces of the leaf, minute, short, roundish or slightly elongated, with a whitish, spreading or somewhat recurved, irregularly lacerated border; spores pale, globose-angular, 15 μ in diameter. II. Spots red-purple, indefinite; sori epigenous, roundish, soon naked, brown; spores subglobose, minutely echinulate, brown, 15–18 by 16–24 μ. III. Spots same; sori roundish or oblong, epigenous and soon naked, or cauline and long covered by the epidermis, blackish; spores oval, elliptical, or oblong, strongly thickened at the apex, broadly rounded or variously pointed, dark brown, 16–18 by 24–30 μ; pedicels about 1½ times the length of the spore, often broad, tinted, especially close to the spore.

On *Œnothera linifolia:* Jackson, April 27, 4342, I., II., III., April 28, 4359, I., II., III.

The æcidia occur on the cauline leaves, affecting all alike, but sparingly on the radical leaves; the uredo- and teleutoforms are mostly confined to the radical leaves. The pedicels of the uredo spores are frequently persistent.

U. spermacoces, (Schw.) Curt.

II., III. Amphigenous, on stems and leaves; spots, none observed; sori numerous, scattered, very prominent, rounded, black, surrounded by the upturned epidermis. II. Spores subglobose, yellowish, very minutely warty, 21–25 by 22–27 μ. III. Spores subglobose, smooth, uniformly very dark colored, 24–27 by 30 μ; pedicels persistent, about 3–4 times the length of the spore.

On stems and leaves of *Diodia teres:* Union, Oct. 25, 1994, Oct. 29, 2122, Nov. 1, 2199. The uredo form was collected in Union Co., Aug. 1880, by C. W. Butler.

U. Rudbeckiæ, Arth. & Hol. (*in lit.*).

Hypophyllous; spots pale, then brown or black, numerous, scattered; sori small, densely clustered, somewhat circinating, slightly raised, clusters plane, epidermis at length vanishing with no remains around the cinnamon-colored sori; spores oblong-obovate, obtuse or obtusely pointed, pallid, about 12 by 20 μ; pedicel slender, hyaline, somewhat longer than the spore.

On *Rudbeckia laciniata:* McHenry, Aug. 24, 1273; Stephenson, Sept. 21, 6084.

The spots resemble some forms of *Puccinia asteris*, the leaf soon breaking away, leaving holes as if eaten by an insect.

U. Howei, Peck.

III. Spots none; sori hypogenous, scattered, indefinitely clustered, often confluent, surrounded by the remains of the ruptured epidermis, blackish purple; spores oval or subglobose, warty, 18–21 by 21–25 μ; pedicels about twice the length of the spore, very fragile, breaking off, leaving a small portion attached to the spore, which therefore appears to be very short-pediceled.

Hypogenous, sori scattered or subconfluent, surrounded by the ruptured epidermis, from one-half to one line in diameter; spores brown, subglobose, roughened with slight indentations (?), .00083 to .0010 in. in diameter.—Peck, 23d Rpt. N. Y. State Museum [1873], p. 58.

On leaves of *Asclepias cornuti:* Champaign, Aug. 11, 1016; Cook, Sept. 8, 2351; Lee, Sept. 9, 5755; Stephenson, Sept. 13,

5826; JoDaviess, Sept. 18, 5983; Rock Island, Sept. 24, 1649; LaSalle, Sept. 28, 6225; McLean, Oct. 19, 1892. *A. tuberosa:* McHenry, Aug. 26, 1318; Champaign, Sept. 20. *A. incarnata:* LaSalle, Sept. 28, 6211.

The pedicels in this species very easily break away. They are not short and permanent in specimens examined, as indicated by Peck, 30th Rep. N. Y. State Mus., p. 75. The minute roughness of the surface is indicative of a uredoform, but no other form has been found, and these are certainly often produced very late in the season. On account of the deciduous pedicels, Peck at first described the species under the generic name of *Trichobasis* (23d Rep. N. Y. State Mus. [1873], p. 58), but in 30th Rpt. [1878], p. 75, transferred it to *Uromyces*, where it doubtless belongs. Perhaps strictness would require the insertion of Peck in parenthesis, as authority for the specific name.

This is *Uromyces asclepiadis*, Cke. (Grevillea V. [1877], p. 152).

U. polygoni, (Pers.) Fckl.

I. Amphigenous; spots minute, inconspicuous; æcidia few, irregularly collected in little groups, small, very short, lacerated border scarcely recurved; spores subglobose or elliptical, epispore thin, tuberculate, 15–18 by 18–21 μ, spermogonia not found. II. Amphigenous; spots yellowish, sori small, scattered, rotund, somewhat elevated; spores subglobose, epispore thick, minutely roughened, 21 by 24 μ. III. Sori cauline, elongated, confluent, dark brown, prominent; spores oval, obovate or oblong, obtuse, epispore smooth, thickened at the apex, 15–24 by 21–35 μ; pedicels long, persistent, sometimes reaching 100 μ.

On *Polygonum aviculare*, var. *erectum:* McLean, May 23, 4745, I., May 25, 4796, I., II., June 1, 4888, I., II., July 11, 2350, II., Oct. 11, 1834, II., III.; LaSalle, June 19, 5238, II.; Champaign, Aug. 11, 1009, II.; McHenry, Aug. 31, 1395, II., III.; LaSalle, Sept. 12, 1488, II., Sept. 13, 1493, II., III.; Union, Oct. 26, 2030, II., III. *P. ramosissimum:* Lake, Aug. 22, 1222; Lee, Sept. 9, II., III.; Union, Oct. 31, 2152, II., III.

The teleutoform occasionally occurs on the midribs of the leaves and (in No. 2152) even on the blade.

In 1797 Persoon (Disp. Meth.) named this plant *Puccinia polygoni*, but afterwards wrote *P. Polygoni Avicularia* (Syn. Fung. [1801], p. 227.) Schröter in 1869 (Rost u. Br. Pilze Schlesiens) adopted the name *Uromyces Avicularia*. Fuckel published the name as *Uromyces Polygoni* in 1869 (Symb. Myc., p. 64).

U. euphorbiæ, C. P.

II., III. Amphigenous; spots purple or yellowish; sori scattered, round, small. II. Sori distinguished by their lighter brown color, spores globose, minutely roughened, pale brown, 15–21 μ in diameter. III. Spores subglobose, oval or obovate, slightly apiculate, warty, 15–18 by 18–25 μ, interspersed with numerous slender paraphyses; pedicels about twice the length of the spore, slender, hyaline, very fragile and deciduous, leaving a small portion attached to the spore.

Leaves generally stained with red or purple; sori amphigenous, subrotund, slightly convex, surrounded by the ruptured epidermis, ferruginous-brown or blackish-brown; spores subglobose, rough, often with a large nucleus, about .0008 in. in diameter; peduncle short, hyaline.—Peck, XXX Rep. N. Y. Mus. p. 90.

On leaves of *Euphorbia maculata:* McLean, July 16, 2352; McHenry, Aug. 22, 1221, Aug. 25, 1301; LaSalle, Sept. 16, 1548 and 1550; Lee, Sept. 8, 5712; Rock Island, Sept. 21, 1616; Jersey, Oct. 14, 6316. *E. hypericifolia:* Adams, July 6, 5431, II., III.; McLean, July 7, 2353, Oct. 6, 1802; Tazewell, July 22, 2354; Piatt, Aug. 15, 1064, Aug. 17, 1104; Rock Island, Sept. 21, 1615; Ogle, Sept. 23, 6143; Union, Oct. 21, 1840. *E. dentata:* Adams, July 6, 5427, II., III., 5428, II., III.; Jersey, Oct. 12, 6263, II., III. *E. heterophylla:* Ogle, Aug. 28, 5641, II., III., Sept. 23, 6144, Sept. 28, 6182, II., III.; Lee, Sept. 9, 5754, II., III. *Euphorbia sps.:* McHenry, Sept. 1, 1409.

The pedicels are deciduous, as are those of *U. Howei*, Peck, and the surface of the spore is similarly roughened. *Æcidium euphorbiæ*, Pers., accompanies the *Uromyces* in Nos. 1064, 1548, 1616, and 2353, but it is believed by most botanists to have no connection with this *Uromyces*.

The synonymy of this species is discussed by Professor Farlow in the Bulletin of the Bussey Institution, II, p. 245.

U. caladii, (Schw.) Farlow.

I. Æcidia scattered over the whole under surface of the leaf, short, with a spreading border; spores subglobose to elliptical, angular, minutely roughened, 15–18 by 18–24 μ; spermogonia also hypophyllous, scattered, preceding and accompanying the æcidia. II., III. Amphigenous; sori scattered, round or oblong, often long remaining partly covered by the epidermis, frequently confluent. II. Spores pyriform, truncate at the base, epispore thick, slightly thicker at the apex, conspicuously echinulate, 15–21 by 25–32 μ. III. Spores oval, subglobose or pyriform, smooth, apiculate, 16–21 by 25–32 μ; pedicels about as long as the spores, very fragile and deciduous, leaving a small portion attached.

On *Arisæma triphyllum:* McLean, May 23, 4755, I., Aug. 1, 2359, III., Aug. 6, 2358, III.; LaSalle, June 15, 4991, I. *A. dracontium:* Union, April 14, 4098 (spermogones), April 17, 4135, I., April 29, 4394, I.; Jackson, April 18, 4164, I., April 19, 4193, I.; Pulaski, May 1, 4399, I., II., May 2, 4423, I, May 6, 4527, I., II., III., May 10, 4590, I.; Johnson, May 12, 4633, I., II.; McLean, May 23, 4754, I., July 20, 2357, III., July 29, 2356, III.; LaSalle, June 21, 5258, I., II., III.; Adams, July 3, 5391, II., III., July 5, 5410, III., July 6, 5435, II., III., July 7, 5445, II., III., July 10, 5459, I., III.; Tazewell, July 22, 2355, III.; Piatt, Aug. 17, 1114, III.; Kane, Aug. 30, 1384, III.; Rock Island, Sept. 24, 1642, III. *Peltandra virginica:* Indiana, near Cook Co. line, Sept. 7, 1456, II., III.

The following is the synonomy of this species: *Uredo Caladii*, Schw. Syn. Fung. Car. [1822], No. 480. *Cæoma* (Uredo) *Ari Virginici*, Schw. Syn. N. Am. Fungi [1834], No. 2839. *Uromyces Peltandræ*, Howe. Bull. Torr. Bot. Club, V. [1874], p. 43. *Uromyces Ari-Virginici*, Howe. l. c., p. 43. *Uromyces Pontederiæ*, Ger. l. c. VI. p. 31. *Uromyces Arisæmæ*, Cke. l. c., p. 32.

Schweinitz was probably mistaken at first in his host plant, and means to correct the error by changing the specific name to *Ari Virginici* in the N. Am. Fungi. His description in the

latter work shows that his specimens were the teleutoform, and priority requires the name *Uromyces caladii* (Schw.) as used by Farlow (Ellis N. Am. Fungi No. 232 [1879].

U. pyriformis, Cke.

III. Spots none; sori amphigenous, frequently arranged in an ellipse, elongated, very dark; spores pyriform, obtuse, epispore smooth, thickened at the apex, 15–20 by 25–23 μ; pedicel half as long to as long as the spore, colored.

Amphigenous, erumpent, sori linear, sometimes confluent, rather pulverulent, purple-brown, epispore thickened above; pedicels rather short, thick, persistent, colored in the upper portion.—Cooke, XXIX. Rep. N. Y. Mus. p. 69.

On leaves of *Acorus calamus:* Lake, Aug. 27, 1339; Cook, Sept. 5, 1434, Sept. 6, 1449, Sept. 7, 1459.

Mr. Peck remarks after the above description, "The species is very closely allied to *U. sparganii*, but appears to differ in habit." It is very doubtful whether it is distinct.

U. spharganii, C. & P.

III. Spots inconspicuous or none; sori amphigenous, scattered or in elongated clusters, round or elongated, often confluent, dark, pulverulent; spores pyriform or oblong, apex rounded or truncate, epispore smooth, strongly thickened at the apex, 15–20 by 24–32 μ; pedicels colored, half as long to as long as the spore.

Sori minute, oblong, crowded, black, spores pyriform or oblong-pyriform, about .001 in. long; pedicel colored, shorter than or equal to the length of the spore.—Peck, XXVI. Rep. N. Y. Mus. p. 77.

On both sides of leaves of *Sparganium eurycarpum:* Cook, Sept. 6, 1450, Sept. 8, 1450.

U. erytheronii, (DC.)

I. Spots purplish, inconspicuous; æcidia few, single or in small clusters or lines, short, with a narrow, delicate, many-lobed border; spores subglobose or oval, somewhat angular, smooth or obscurely roughened, 15–21 by 21–27 μ. III. Spots

none; sori amphigenous, few, scattered, elliptical, usually remaining partly covered by the epidermis: teleutospores subglobose to oblong, apiculate, marked with longitudinal striæ, 15–21 by 20–30 μ: pedicels fragile, deciduous.

On leaves of *Allium striatum:* Union, April 12, 4028, I., III., April 15, 4108, I., III., April 17, 4139, I., III.; Jackson, April 28, 4365.

The only perceptible difference between the Illinois specimens and those on *Erythronium* from Europe is in the small number of æcidia in a cluster.

U. junci, (Schw.) Tul.

II., III. Sori amphigenous, scattered or sometimes confluent, roundish or elongated, prominent, long covered by the epidermis, and after the rupture of the latter its edges conspicuous, the uredosori yellowish brown, the teleuto sori dark brown. Uredospores subglobose, elliptical or sometimes pyriform, echinulate, 12–18 by 18–21 μ, occasionally longer. Teleutospores clavate or irregularly elliptical, usually widest towards the top, smooth: apex obtuse, rounded or truncate, strongly thickened, deep brown: base narrowed: pedicel somewhat colored, nearly or quite as long as the spore; 14–18 by 21–32 μ.

On *Juncus tenuis:* Pulaski, May 1, 4404, II.: Stephenson, Sept. 13, 5830, II., III.

The teleutosori are often much infested with *Darluca filum*, a parasite on a parasite. On *Juncus tenuis* this seems especially true.

U. scirpi, Burrill.

II., III. Amphigenous, spots brown, indeterminate; sori long covered by the epidermis, minute and rounded, or larger, oblong, sometimes confluent end to end, forming clusters up to one fourth of an inch long, nearly black. Spores among the teleutospores few, irregularly elliptical, yellowish brown, sparsely echinulate, 15–20 by 27–36 μ. III. Spores clavate-elliptical, widest at centre, mostly pointed, brown, apex darker, and thickened, 18 by 32–42 μ; pedicel stout, subhyaline, about the length of the spore.

On leaves of *Scirpus fluviatilis:* Champaign, Aug. 13, 1031, II., III.: Piatt, Aug. 16, 1088; LaSalle, Sept. 16, 1551, Sept. 20, 1597; Ogle, Sept. 22, 6114, II., III.

The leaves are thickly mottled with conspicuous brown spots, not definitely circumscribed. The appearance is nearest to that of *Uromyces spartinæ*, Farlow (*U. junci*, var. *spartinæ*, Ellis Exs. No. 239), of anything found, but it is sufficiently distinct in the characteristics of the sori, and in the larger, differently shaped spores.

U. acuminatus, Arthur.

II., III. Hypogenous, sori scattered, elongated, soon naked, ruptured epidermis ragged, conspicuous. Uredospores globose or oval, somewhat echinulate. Teleutospores very irregular, subglobose to clavate, sometimes rounded or truncate, but usually conspicuously and variously pointed; epispore thin, smooth, yellowish brown, 15–18 by 24–39 μ; pedicel rather slender, somewhat colored, from one to three times length of spores.

I. Unknown. II., III. Sori linear, narrow, elongated, on the under surface of the leaves plane or slightly convex, sunken, soon naked; encircling epidermis somewhat conspicuous. II. Uredosori yellowish, inconspicuous; uredospores large, round or elliptical, finely and plentifully echinulate, brownish yellow, .00088 to .0012 in. broad by .00102 to .0014 in. long. III. Teleutosori brownish black; teleutospores oblong-club-shape and oblong lanceolate to obovate, smooth, golden brown, darker at the apex, .0006 to .00088 in. broad by .0010 to .00168 in. long; wall thin; apex much thickened, .00032 to .00048 in. thick, more or less obliquely acuminate, or rarely only apiculate, sometimes with two pointed terminations, one longer than the other, very rarely obtuse or rounded; base narrowed or only acute; pedicel of uniform thickness, as long as the spore, or shorter, very rarely longer, colored.—Arthur, Bull. Minn. Acad. Nat. Sci. Vol. XI. p. 35.

On leaves of *Spartina cynosuroides:* McHenry, Aug. 26, 1326, I., II.; LaSalle, Sept. 16, 1559.

Among the *Uromycetes* inhabiting grasses this is readily distinguished by the irregular and peculiar shape of the teleutospores. While some are no longer than wide, many are oblong or nearly lanceolate, while the apex has a multitude of forms: sometimes straight, sometimes acutely acuminate: often

turned sidewise, beak-like; not seldom double; and occasionally suggesting the appendages at the apex of the teleutospores of *Puccinia coronata.*

U. graminicola, Burrill.

II., III. Sori amphigenous, but more common on under surface, scattered, small, oblong or linear, soon uncovered, the ruptured epidermis ragged, but usually its remains plainly apparent. Uredosori yellow, teleutosori blackish brown; uredospores spheroidal or oval, minutely echinulate, 15–18 by 18–22 μ. Teleutospores variable, subglobose, oval or oblong, smooth; apex rounded or angular, thickened, 12–18 by 21–30 μ; pedicel somewhat colored, thick, scarcely tapering below, once to twice the length of the spore.

On *Panicum virgatum:* McLean, July 20, 2347, II., III., Oct. 11, 1832; Champaign, Aug. 13, 1036, II., III.; McHenry, Sept. 1, 1407. *Elymus virginicus:* Piatt, Aug. 10, 1001.

This species resembles somewhat closely *U. junci*, (Schw.) Tul., from which, however, it is sufficiently distinct aside from the difference in host. Compared with the latter the present species has larger and sooner opened sori, the uredospores have finer echinulations, and the teleutospores are usually shorter, rounder, with apex less produced and pedicel very distinct, being thicker, longer, and less tapering below. Among the *Uromycetes* on grasses this seems distinct from *U. Peckianus*, Farlow, to which it bears some resemblance. The latter has the teleutospores more nearly subglobose, epispore uniformly thickened, not produced at apex, and with longer and different pedicels. Perhaps the nearest approach is to *U. spartinæ*, Farlow, which, however, has much larger and thicker-walled uredospores, and the teleutospores are lighter colored, more regular in shape, with longer and more slender pedicels.

PUCCINIA, Pers.

Teleutospores two-celled, one above the other, brown, produced on permanent pedicels which arise in dense masses from a cushion-like layer of irregular cells beneath the epidermis.

The characteristics of the genera *Uromyces* and *Puccinia*

are substantially identical, except that in the former the teleutospore consists of a single cell, and in the latter of two cells, formed by a horizontal septum usually placed somewhat below the middle. The æcidium and uredo forms of the two genera are not distinguishable. That the two genera are very closely allied is also shown by the fact that in some species of *Uromyces* two-celled spores are met with, while, especially when not fully nourished, single-celled spores are quite common in certain *Pucciniæ*. Occasionally more than two cells are observed in true *Puccinia* spores, but in this case there is less difficulty in determining the classification, because the spores in genera characterized by two or more transverse septa (*Phragmidium*, etc.) are considerably different in appearance.

In exact strictness each cell in all these divided forms should be called a spore, for each is independent of the others in germination. Some have even called the whole body a spore sack (ascus), and the single cells spores; but there is no distinct wall for the former.

The genus has been divided as follows:—

1. *Leptopuccinia.*—Only teleutospores produced, which are firmly attached to their stems and germinate soon after maturity; sori quite firm, mostly hemispherical.

2. *Micropuccinia.*—Only teleutospores known, these readily separating from the pedicels, germinating only after a long period of rest.

3. *Hemipuccinia.*—Uredo- and teleutospores known, æcidia not known.

4. *Pucciniopsis.*—Æcidia and teleutospores known, uredo wanting.

5. *Eupuccinia.*—Æcidia, uredo- and teleutospores known.
   a. *Autopuccinia.*—All sporeforms on the same plant.
   b. *Heteropuccinia.*—Æcidia (and spermagonia) on a different host species from the uredo- and teleutospores.

The third division now undoubtedly contains many species which further information will transfer to the fifth, and the same may be said, with less probability, of the fourth. Since this classification is not applied in what follows, we simply cite as examples of the first: *P. anemones-virginianæ*, Schw.; *P.*

circeæ, Pers.: *P. asteris*, Duby: of the second—none in the list known: of the third: *P. pruni-spinosæ*, Pers.; *P. scirpi*, DC.: *P. maydis*, Cda.: of the fourth: *P. aculeata*, Schw.; of the fifth, first division: *P. tanaceti*, DC.: *P. flosculosorum*, *P. menthæ*, Pers., second division: *P. caricis* (Schum.); *P. graminis*, Pers.

P. anemones-virginianæ, Schw.

III. Spots dark brown: sori hypophyllous, prominent, small, but commonly in dense, wart-like clusters, dark-brown; spores linear-oblong, obtuse, slightly constricted, light-brown below, darker above, the upper cell the shorter, and with the epispore thickened at the apex, 12–15 by 35–55 μ; pedicels very short, colored.

Spots none; sori scattered, rather large, so compact that they appear solid, black; spores at length easily breaking up. The sori are scattered over the whole leaf, and at first lutescent, and as if sunken.—Schweinitz N. Am. Fungi, No. 2937, p. 296.

On leaves of *Anemone cylindrica:* McHenry, Aug. 23, 1241, Sept. 1, 1404; Cook, Sept. 5, 1441; LaSalle, Sept. 13, 1495. *A. Virginiana:* Piatt, Aug. 17, 1115; Union, Aug. 17, 2519; McHenry, Aug. 27, 1335; McLean, Sept. 6, 5668; LaSalle, Sept. 12, 1471, Sept. 20, 1598; Lee, Sept. 21, 5797; JoDaviess, Sept. 16, 5953, Sept. 18, 5991, Sept. 20, 6037.

The spores are light colored and fragile, when dry, much shrunken. Only telentoform known.

Schweinitz first gave the name cited above (Syn. Fung. Car. [1822] p. 46), and afterward (N. Am. Fungi [1834] p. 296) changed it to *P. solida*.

P. ranunculi, Seymour.

III. Amphigenous, but mostly epiphyllous. Sori irregularly associated, often crowded but scarcely confluent, occupying large areas or the whole of the leaf surface, little elevated, circular, powdery, surrounded by the upturned edges of the epidermis, æcidium-like, cinnamon-brown; teleutospores broadly elliptical, usually little or not at all constricted at the septum, ends rounded, vertex more rarely furnished with a low,

pale apiculus, thickly but minutely tuberculate, 18–24 by 22–39μ; pedicel hyaline, fragile, short, sometimes more or less lateral.

On *Ranunculus repens:* Riverside, Illinois, near Chicago, June 2, 1883, J. C. Arthur.

The little warts of the epispore are scarcely or not at all visible in soaked specimens. The teleutospores sometimes germinate in the sorus in June. One-celled specimens are not uncommon, and some vary widely from the described type.

P. podophylli, Schw.

I. Hypogenous. Spots indefinite, mostly large, sometimes confluent over the whole leaf, yellow; æcidia densely crowded, very short, deeply and numerously split and much recurved, very fragile; æcidiaspores subglobose or elliptical, epispore very thin, minutely tuberculate, 16–27 μ; spermagonia minute, rather sparsely scattered, opposite the æcidia. (*Æcidium podophylli*, Schw.) II. Unknown. III. Amphigenous on leaves and stems, on the former mostly beneath; sori small, rounded, usually more or less confluent; spores ovate, obovate or elliptical, beset with straight or curved conspicuous spines, 20–27 by 39–48 μ; pedicel very delicate and fugacious.

On *Podophyllum peltatum:* Union, April 12, 4031, I, April 14, 4085, I., 4086, I., III., April 15, 4107, I., III., April 17, 4130, I., III., April 18, 4167, I., III., April 19, 4174, I., III., April 24, 4244, I., III., April 26, 4302, I., III., 4304, I., III., April 29, 4392, I., III.; Jackson, April 20, 4196, I., III., April 21, 4215, I., III., April 27, 4341, I., III.; Pulaski, May 1, 4400, I., III., 4419, I., May 4, 4482, I., III., May 5, 4496, III., May 6, 4526, I., III.; McLean, July 5, 2279, July 7, 2283, July 12, 2282, Aug. 1, 2281; Tazewell, July 22, 2288; McHenry, Aug. 20, 1140; Lake, Aug. 27, 1348.

Commonly known as *P. aculeata*, Schw., but the above name has priority. The species is readily identified by the spines of the teleutospore. The æcidia occur on the parenchymentous portions of the leaf, and the teleutospores are not unfrequently subsequently produced along the veins and upon the stems, having no apparent mycelial connection with the æcidia. In other cases they are produced either in the midst of the æcidia or in close proximity to them.

P. violæ, DC.

I., II., III. Amphigenous, or often hypogenous. I. Spots definite or more or less diffused, sometimes covering large areas of the blades and of the petioles; æcidia irregularly (usually densely) clustered, short, rather coarsely and deeply lacerated and irregularly recurved; spores subglobose, epispore very thin, minutely tuberculate, 12–18 μ; spermagonia not found. II., III. Sori sparsely scattered, or collected in little irregular groups upon discolored spots (Æcidium violæ, Schum.). II. Spores subglobose, elliptical or obovate, epispore thick, sharply echinulate, cinnamon-brown, nearly as dark as the teleutospore, 18–24 μ. II. Spores usually broadly elliptical, frequently irregular, little or not at all constricted at the septum, which is thick, vertex thickened, furnished with a conspicuous, tinted, usually obtuse apiculus, and a somewhat similar projection sometimes occurs on the side of the under segment near the septum, base mostly obtusely rounded, epispore rather thick, conspicuously but rather finely tuberculate, 18–24 by 26–37 μ; pedicels hyaline, fragile, sometimes more or less lateral, not longer than the spore.

On *Viola cucullata:* McLean, Aug. 4, 2284; McHenry, Aug. 22, 1207, II., III., Aug. 31, 1391; Lake, Aug. 29, 1360; Stephenson, Sept. 14, 5888, II., III.; JoDaviess, Sept. 20, 6034, III.; Ogle, Sept. 23, 6137, III. *V. striata:* Jackson, April 18, 4163, I., April 19, 4173, I.; Union, April 24, 4245, I., III. *V. pubescens:* McLean, June 24, 5285, II., III., July 15, 2286, Aug. 1, 2285, Aug. 6, 2287, Adams, June 28, 5326, II., III. *Viola sp.:* Kane, Aug. 30, 1381.

P. Mariæ-Wilsoni, Clinton.

I. Amphigenous. Æcidia regularly scattered, often closely associated over large areas of the host; peridia laciniated and excurved; spores subglobose, epispore thin, finely echinulate, 15–18 μ; spermogonia scattered among the æcidia. III. Sori hypogenous, irregularly clustered, little elevated, long covered by the epidermis; spores irregular and various, more often elliptical, not constricted at septum, the latter strongly developed; apex obtuse, sometimes furnished with a

very short apiculus, epispore thick, conspicuously, though rather finely tuberculate, 21–27 by 30–48 μ: pedicel hyaline, fragile, short.

Caeoma (*Æcidium*) *Claytoniatum*, L. v. S. Almost simple and without spots, occupying the whole leaf. Pseudoperidia broad, scattered. Spores orange.—Schw. N. Am. Fung., No. 2892, p. 294.

Puccinia Mariæ-Wilsoni, Clinton. Amphigenous; spots none; sori scattered or clustered unequal, at first covered by the epidermis, then surrounded by its ruptured remains; reddish brown; spores subelliptical, scarcely constricted, crowned with a pustule, .0013–.0018 in. long, .0007–.0008 in. broad.—Peck, 25 Rep. N. Y. State Mus. p. 115.

On *Claytonia Virginica*: Both forms were collected at Riverside, Illinois, near Chicago, June 2, 1883, by J. C. Arthur.

This compound specific name ought not to be tolerated. Whatever may be said of the Schweinitzian and other old specific names composed of the binomial name of the host, there is no excuse in such a case as the present for disregarding a well-established and appropriate rule.

In the accessible descriptions nothing is said of the tuberculate surface of the teleutospores.

P. heterospora, B. & C.

III. Spots purple, definite; sori hypogenous, small, densey and definitely clustered, soon naked, ruptured, epidermis inconspicuous; spores subglobose or rarely elongated, mostly single-celled, but frequently septate in any direction, epispore smooth, gradually thickened toward the apex, diameter 18–27 μ: pedicel hyaline, slender, diminishing below, about three to five times the length of the spore.

Sori minute, collected in orbicular groups, brown; spores subglobose, with the pedicel attenuated downward, subequal, at length septate. —Berkeley, Journ. Linn. Soc. Vol. X., p. 356.

On *Sida spinosa*: Union, Sept. 17, 1882, 5033. F. S. Earle.

This is *Uromyces pulcherrima*, B. & C. (Grev. III. [1874] p. 56, also *U. Thwaitesii*, B. & Br. Journ. Linn. Soc. XIV. [1875] p. 92,).

The original description by Berkeley and Curtis is in Jour. Linn. Soc. X. [1869] p. 356. See A. B. Seymour, Botanical Gazette, 1884, p. 357.

The species is properly a *Puccinia* since the septate cells, though usually less in number than the simple ones, are numerous and normal in character — evidently the highest development of the plant.

P. nolitangeris, Cda.

Hypophyllous. II., III. Sori minute, scattered uredosori yellowish; teleutosori brown; uredospores subglobose, obscurely echinulate, diameter 16–19 μ; teleutospores elliptical to oval, but irregular, rounded at both ends and slightly constricted, with a prominent hyaline apiculus, 15–18 by 25–33 μ; pedicels hyaline, very fragile and deciduous, apparently about as long as the spores.

Spots irregular, confluent, flavescent; sori gregarious, rufo-fuscous; spores oblong, obtuse or attenuated, apiculate, amœne fuscous, hyaline; epispore simple, thin; nucleus grumulose; oil globules white; terminal apiculus hyaline, whitish; pedicel rudimentary, almost none, white. Length of spore, .00134.—Corda, Icon. IV, p. 16.

On leaves of *Impatiens fulva:* La Salle, Sept. 12, 1479, II, III, Sept. 14, 1536, II, III. *I. pallida:* La Salle, Sept. 12, 1480, II., III., Sept. 17, 1590, II., III. *Impatiens:* LaSalle, Sept. 30, 6245, II., III.

This species has now been found for four successive years in the "Lower Park," at Deer Park, LaSalle Co., though diligent search fails to discover it in any of the similar localities in that region, nor has it been found elsewhere in the State.

P. amorphæ, Curt.

II. Sori usually epiphyllous, small, few, clustered, surrounded by numerous closely packed, clavate, incurved, brown paraphyses; spores ovate or oval, minutely echinulate, 12–15 by 18–21 μ. III. Amphigenous; sori small, scattered, or above clustered and circinate; paraphyses as in II; spores much constricted, cells globose, enveloped by a thick, hyaline, readily separable coat, without latter, 24–30 by 42–45 μ; pedicels hyaline, fragile.

Amphigenous, sori scattered and approximate in yellow spots, subrotund, black; spores compact, oval, rarely globose, constricted in the middle, opaque; pedicel short or none....Sporidia remarkable for a

loose, transparent, vesicular (?) epidermis, often enclosing and bordering the opaque nucleus.—Curtis, Am. Jour. Sci. & Arts, 2 Ser., Vol. VI. p. 353.

On leaves of *Amorpha fruticosa:* Adams, July 11, 5503, II.: McLean, July 29, 2289, II., III., Oct. 13, 1859; Piatt, Aug. 15, 1076, Aug. 16, 1080, II., III., Aug. 17, 1133; Lee, Sept. 9, 5765, II., III., 5766; LaSalle, Sept. 12, 1476, II., III., Sept. 13, 1515, Sept. 14, 1535; Ogle, Sept. 25, 6162; Fulton, Oct. 1, 1772. *A. canescens:* McHenry, Aug. 24, 1264, Aug. 25, 1290, Aug. 27, 1332, II., III.: Lake, Aug. 27, 1345; Lee, Sept. 11, 5785; Stephenson, Sept. 14, 5891; JoDaviess, Sept. 15, 5915; Ogle, Sept. 22, 6097.

This is *Uropyxis amorphæ*, Schröter; but aside from the peculiar coating of the teleutospore there is nothing to separate the species from *Puccinia*. The uredoform would have been considered a good *Lecythia*, and is much like that of *Melampsora* on willows. The teleutosori on the upper side of the leaf are compact, the spores crowded together. On the under side the spores are diffusely associated in the sori.

P. pruni-spinosæ, Pers.

II., III. Hypophyllous. Spots above small, scattered or confluent, II. yellow, III. purple; sori scattered, small, rounded, teleutosori purplish brown; uredospores oblong or clavate-elliptical, smooth, 15–18 by 32–39 μ; paraphyses pedicel-like, then swollen at the end and often curved; teleutospores deeply constricted, the segments often globose, easily separable or more closely united and irregular, strongly echinulate, 21–24 by 24–39 μ; pedicels hyaline, very fragile, about the length of the spore; the paraphyses numerous, much enlarged above, and brown.

Scattered, minute, punctiform, spores globose, twin; pedicels very short.—Pers. Syn. Fung. p. 226.

On leaves of *Prunus Americana:* Lake, Aug. 29, 1361; McHenry, Aug. 31, 1387; Lee, Sept. 9, 5759; LaSalle, Sept. 13, 1502; JoDaviess, Sept. 16, 5954, Sept. 18, 5988, Sept. 19, 5994; Ogle, Sept. 25, 6171. *P. Virginiana:* McLean, Aug. 6, 2290. *P. serotina:* Ogle, Sept. 22, 6112, II., III., Sept. 26, 6191, II., III.

The uredoform is *Uromyces prunorum*, Fckl. The shape and attachment of the cells of the teleutospores vary on different hosts. On *Prunus Americana* the cells are nearly or quite globular, and easily separated, while on P. *serotina* they are well joined and variable.

Nees (Syst. d. Pilze u. Schwämme [1816]), under the generic name of *Dicæoma*, separated the *Puccinia* species in which the spores spontaneously divided at the septum before germination. *P. pruni-spinosæ* belongs to this group.

P. Peckiana, Howe.

III. Hypogenous. Sori small, scattered, few or many, sometimes sparingly confluent, cinnamon-brown, powdery; spores in one view more or less triangular, in the other, at right angles to the first, elliptical, not constricted at segment, upper segment triangular, with a small hyaline, obtusely rounded apiculus, lower segment in side view somewhat quadrate, with two basal projections, to one of which the pedicel is attached, and the other is terminated with a hyaline apiculus similar to that of the upper segment. 22–27 (base) by 36–45 μ; pedicel hyaline, fragile.

On *Rubus villosus:* Urbana, July 24, 1884, T. J. Burrill.

This may be the teleutoform of what is called *Cæoma nitens*, Schw., the "orange rust" of the blackberry, so well known to horticulturists. The *Puccinia* has also been found on raspberry leaves in New York, and the *Cæoma* sometimes occurs on the latter host. *Puccinia tripustulata,* Peck, is the same species, and so admitted by the author of the latter name.

P. tiarellæ, B. & C.

III. Amphigenous. Spots small, distinct, reddish brown; sori scattered, circular, prominent, on the petioles more or less elongated and sometimes confluent, chestnut-brown; spores elliptical, constricted at the septum, vertex much thickened, and usually prominently pointed, base mostly obtusely rounded, epispore rather thin, smooth, 12–18 by 21–36 μ; pedicel nearly hyaline, very slender, once to twice as long as the spore.

On *Mitella diphylla:* Kane, Aug. 30, 1382.

Thanks are due to Professor W. G. Farlow for the comparison of this with original specimens.

P. proserpinacæ, Farlow.

II., III. Amphigenous, but often only hypophyllous. Sori rounded, scattered or collected in irregular groups, sometimes, especially along the veins, confluent, rarely naked, the uredosori surrounded by the remains of the ruptured epidermis, the two kinds nearly of the same color, chestnut-brown, the teleutosori becoming grayish from the germinating filaments; uredospores obovate, pale cinnamon-colored, epispore rather thick, sharply echinulate, 15–21 by 24–30 μ; teleutospores oblong, sometimes narrower, usually gradually contracted at the septum, apex thickened and rounded or pointed, epispore thin, smooth, cell contents granular, pale brown, 15–21 by 35–52 μ; pedicel nearly hyaline, usually about half the length of the spore.

Sori round, scattered, soon becoming naked. Uredospores yellowish brown, oval, echinulate, 20–26.5 μ in diameter, average 22–23 μ. Teleutospores brown, densely packed and germinating in the sorus, short-stalked, clavate, contracted somewhat at the septum, apex rather acute, with thickened cell wall, 38–5.3 μ by 17–21 μ.—Farlow, Proc. Am. Acad. Arts & Sci., Vol. XVIII., p. 80.

On *Proserpinacea palustris:* Ravenswood, near Chicago, Sept. 4, 1883. J. C. Arthur.

P. circææ, Pers.

III. Hypophyllous. Spots definite, purple or brown; sori rounded, clustered, and more or less circinate; spores oblong, slightly constricted, smooth, obtusely pointed, apex thickened, narrowed at base, 15 by 24–66 μ; pedicel somewhat colored, equalling or exceeding the length of spore.

Scattered, wart-like, chestnut-color, spores ovate and acute.—Pers. Syn. Fung. p. 228.

On *Circæa Lutetiana:* Johnson, May 11, 4611; Adams, June 27, 5309; McLean, July 15, 2295, July 20, 2293, 5602, July 27, 2291, Aug. 1, 2294; Tazewell, July 22, 2292; Piatt, Aug. 17, 1110; McHenry, Aug. 20, 1170, Aug. 22, 1204; Kane, Aug. 30, 1379; Lee, Sept. 11, 5767; LaSalle, Sept. 17, 1567,

Sept. 30, 6251; Stephenson, Sept. 13, 5832; JoDaviess, Sept. 15, 5917, Sept. 19, 5995; Ogle, Sept. 23, 6138. *C. alpina:* Kane, Aug. 30, 1380.

On *Circæa Lutetiana* the sori are marked, while on *C. alpina* they are distinct, smaller, and often circinate.

P. pimpinellæ, (Strauss) Lk.

II., III. Amphigenous. Sori rather large, round, scattered, soon naked. Uredospores globose or ovate, minutely roughened, thick-walled, 18–21 by 24–27 μ; teleutospores broad, ends rounded, little constricted, surface roughened with mesh-like depressions, 18–21 by 29–35 μ; pedicel hyaline, fragile, sometimes more or less lateral.

Spots obliterated, sori subrotund, scattered, amphigenous, spores cinnamon, of two forms, ovate and obovate, short pedicelled.—**Link**, Linn. Sp. Plant, VI., P. II., p. 77.

On *Osmorrhiza longistylis:* Fulton, 2269, II., III. (Wolf); Adams, June 30, 5359. *O. brevistylis:* LaSalle, Sept. 29, 6231.

Peck (29 Rep. N. Y. State Mus. [1878] p. 73) mentions without describing *P. osmorrhizæ*, C. & P., on *Osmorrhiza*. Previously (25 Rep. N. Y. State Mus. [1873] p. 112) he describes *P. myrrhis*, Schw. (N. Am. Fungi, [1834] p. 296) on the same host plants. Schröter (Hedw. XIV. [1875] p. 169) shows the latter to be the same as *P. pimpinellæ*, Lk. (Spec. Plant. II. [1824–25] p. 77). Winter (Rabh. Kryptog. Fl. I. [1882] p. 212) unites these two with *P. chærophylli*, Purton, (Brit. Plants III. [1821] No. 1553), and other supposed species under the name of *P. pimpinellæ* (Strauss). The above mentioned specimens collected by Wolf were identified by Peck as *P. osmorrhizæ*, C. & P., but they agree with his description of *P. myrrhis*, Schw., and with Thümen's specimens, including those of *P. myrrhis*, Schw. (Mycoth. Univ. No. 1327), collected in New York by Gerard, and *P. chærophylli*, Purton, (Mycoth. Univ. No. 1229).

P. galiorum, Lk.

I. Æcidia hypophyllous, small, short, reflexed at summit; spores subglobose or broadly oval, smooth, 15–21 μ. II. Not yet found in Illinois. III. Amphigenous; sori usually scattered

singly on leaves and stem, round or somewhat elongated; spores irregular, elongated, mostly oblong or clavate-elliptical, smooth, apex strongly thickened, obtuse or variously pointed, sometimes broadly truncate, usually narrowed to the base, 18–21 by 23–45 μ; pedicels hyaline, about the length of the spore.

On *Galium concinnum:* Champaign, Aug. 13, 1037; Piatt, Aug. 15, 1062, Aug. 17, 1116; McHenry, Aug. 20, 1188, Aug. 22, 1201, Aug. 23, 1237, Aug. 28, 1306; Lee, Sept. 8, 5723; La Salle, Sept. 13, 1519, Sept. 30, 6253; Stephenson, Sept. 13, 5831; JoDaviess, Sept. 16, 5955; Ogle, Sept. 23, 6137½; Henry, Sept. 28, 1727; Jersey, Oct. 14, 6039. *G. triflorum:* Champaign, June 9, 4935, I., III., June 10, 4957, I., III.; Adams, June 27, 5308, I., III., June 29, 5343, I., III.

Single-celled teleutospores are rather numerously found.

P. tenuis, Burrill.

I. Hypophyllous, rarely also epiphyllous: æcidia clustered in little irregular groups or sparsely scattered, very small, short, the narrow border irregularly lacerated and recurved; spores subglobose, very minutely tuberculate, 14–18 μ. (*Æcidium tenue*, Schw.) III. Hypophyllous: spots small, often confluent, mostly yellow, with a broad blackish center; sori sometimes scattered, usually confluent, effused, slightly convex, covered by the epidermis, dull grayish black; spores oblong-clavate, slightly constricted, usually angular or variously conspicuously pointed, 15 by 40 μ; pedicels hyaline or slightly colored, half as long as the spore.

Æcidium tenue, Schw. Spots yellowish, evanescent, very small; peridia scattered, little elevated, but, what is peculiar, amphigenous—closed on the upper surface, open on the lower; spores pallid.—Schweinitz, N. Am. Fungi, No. 2889.

On leaves of *Eupatorium ageratoides:* Johnson, May 11, 4612, I.; McLean, Aug. 6, 2302; Champaign, Aug. 13, 1058; Piatt, Aug. 17, 1103; Lake, Aug. 27, 1340.

P. Kuhniæ, Schw.

II., III. Amphigenous: sori not prominent nor compact, often ragged from the uneven height of the spores. II.

Spores with the teleutospores, subglobose to oblong, echinulate, yellowish brown, 16–27 by 27–30 μ. III. Spores quite uniform, rounded at both ends, broad, with a very short, nearly hyaline apiculus, and sometimes a simular projection on the side of the lower segment, thick walled, dark colored, smooth, 30 by 44 μ; pedicels as long as 90 μ.

Spots none; sori amphigenous, pulvinate, densely aggregated, blackish brown; spores rather large, broad, long pedicelled.—Schweinitz, N. Am. Fungi, No. 2931, p. 296.

On *Kuhnia eupatoriodes:* Lee, Sept. 9, 5761, II., III.; La Salle, Sept. 12, 1478, Sept. 14, 1542; Stephenson, Sept. 14, 5889, II., III.; Champaign, Sept. 23; McLean, Oct. 7, 1823; Jersey, Oct. 12, 6270.

P. conoclinii, Seymour.

II., III. Mostly hypophyllous; spots small, purple, often confluent over large areas, becoming pale; sori scattered, sparse or very numerously associated, not often confluent, uredosori cinnamon-brown; teleutosori dark reddish brown; uredospores subglobose to oval, sharply echinulate, 18–27 μ; teleutospores broadly oval, little constricted, ends rounded, walls thick, warty, 27 by 32–42 μ; pedicel nearly hyaline, firm, crooked, very long, about three times the length of the spores.

On *Conoclinium cælestinum:* Pine Hills, Union Co., Sept. 11, 5034, II., III. F. S. Earle.

This is *P. centaureæ*, DC. of Berkeley's Notices of North American Fungi (Grevillea III. p. 53) ascertained by examination of the original specimens in Herb. Curtis, but differs from other authentic specimens bearing this name.

P. asteris, Duby.

III. Hypophyllous. Sori densely crowded in round, distinct, and firm clusters, the latter scattered, few or many, light to dark brown; spores smooth, clavate, gradually narrowed to the septum and toward the base, upper segment widest, apex thickened, rounded or pointed, 15–18 by 33–45 μ; pedicel nearly hyaline, usually somewhat shorter than the spore.

Spots above yellowish, sori large, fuscous, orbicular and elongated, convex, compact, and powdery, scattered, hypophyllous, surrounded by

the ruptured epidermis. Stipe white, filiform, nearly equaling the elongate elliptical spore, which is constricted in the middle, lower article elongate-turbinate, upper obtuse, elliptical or ovate-globose.—Duby, Botanicon Gallicum, Vol. II. p. 888.

On leaves of *Aster shortii:* McLean. July 15. 2308 and 2309. Aug. 4. 2307. Aug. 6. 2306. *A. sagittifolius:* McLean. July 7. 2313 and 2315. July 12. 2319. July 15. 2315. July 16. 2316. July 29. 2318. Aug. 1. 2320. Aug. 4. 2310. Aug. 6. 2311. 2312. Oct. 19. 1894; Ogle. Sept. 23. 6141; Fulton. Oct. 3. 1737. *A. miser:* McLean. Oct. 11. 1833. *A. Novæ-Angliæ:* McLean. July 25. 2314: Stephenson. Sept. 13. 5836. *Aster sps.:* McLean. July 7. 2323. July 14. 5537. July 17. 5581. Oct. 6. 1797; Adams. July 10. 5455; Tazewell. July 22. 2321 and 2322; Piatt. Aug. 16. 1083. Aug. 17. 1123; McHenry. Aug. 24. 1269. Aug. 31. 1388.

There is no apparent reason for keeping separate the variable forms known as *P. asteris*, Schw., and *P. Gerardii*, Peck. On *A. sagittifolius* both are found on the same leaf in several instances. The younger more rapidly grown specimens are lighter colored. and there are all degrees of distinctness and confluence of the sori. When on thin leaves the spots quickly die. the spores are very poorly developed. light-colored. thin-walled. and very fragile. In other cases the sori are somewhat circinate in arrangement and not crowded. The central and older ones are covered with the epidermis. the outer. younger. and lighter brown ones burst through and are thus naked. Sori very rarely occur on the upper side of the leaf. On *Aster Novæ-Angliæ* the spores are better developed. plumper. stronger. darker brown. yet on dead spots are the opposite. Here the sori are usually much scattered. not collected in clusters. Sometimes on thin leaves of several species. dead spots soon fall out. leaving more or less rounded holes.

Again. Schweinitz's name (N. Am. Fungi [1834] p. 296) is untenable. having been previously used by Duby (Bot. Gall. [1828-30] p. 888). For this reason the name *P. Gerardii*. much more recently given by Peck (25 Rep. N. Y. State Mus. [1870] p. 91) should be adopted if either. But there is a further question. whether or not the American specimens are specifically distinct from those of Europe. Three names have been

given to the latter, *P. Asteris*, Duby, *P. Tripolii*, Wallr. (Flora Crypt. Germ. [1831-3] II. p. 223), and *P. Asteris*, Fckl. (Symb. Mycol. [1875] p. 53), which have been pronounced synonyms by several botanists, and from the material and descriptions at hand it is impossible to separate from these the American forms. Schröter (Hedw. XIV. [1875] p. 169), after an examination of original specimens, confidently declares that the forms are specifically identical. Cooke (Grevillea III. [1875], p. 169) seems to regard Schweinitz's species as distinct from the European plant, though not supposing *P. Gerardii*, Peck, specifically different from the former. After careful comparison of specimens, all are here referred, as may be seen, to the species called *Puccinia Asteris* by Duby.

P. silphii, Schw.

III. Hypogenous; spots scabious, numerous, scattered, concave, with a raised rim; sori very prominent, wart-like, compact, dull grayish brown; spores irregular, oblong-clavate, conspicuously and angularly pointed, firm, dark colored, but not thick walled, smooth, contents granular, 13 by 40 μ; pedicel tinted, firm, about the length of the spore. The leaves are often thickly spotted and scarred by the fungus, and large patches of sori occur also on the stems.

Spots rather small, purple; sori thick, pulvinate, confluent, aggregated, black; spores compact, of uniform color.—Schweinitz N. Am. Fungi, No. 2929, p. 296.

On *Silphium terebinthinaceum:* McLean, June 23, 5275. *S. integrifolium:* McLean, June 23, 5276, July 14, 5536, July 16, 2338, July 26, 2382; Champaign, Aug. 13, 1039; McHenry, Aug. 26, 1322, Aug. 27, 1337, Aug. 31, 1389, Sept. 1, 1408; LaSalle, Sept. 16, 1558. *S. perfoliatum:* McLean, May 30, 4823; June 19, 5265, July 17, 5579; Adams, June 30, 5368; McHenry, Aug. 24, 1272; Lee, Sept. 9, 5763.

P. xanthii, Schw.

III. Hypophyllous. Sori small, mostly closely clustered in spots or patches; spores smooth, oblong, evidently constricted, apex slightly thickened, round, or beak-like, 15–21 by 36–51μ; pedicel slightly colored, usually shorter than spore.

On leaves of *Ambrosia trifida:* McLean, July 5, 2383, July 29, 2336, Aug. 4, 2384; Champaign, Aug. 12, 1066; Piatt, Aug. 17, 1109; Fulton, Oct. 3, 1734. *Xanthium strumarium:* McLean, July 4, 2387, July 6, 2337, July 11, 2388, July 14, 5538; July 29, 2385, Oct. 6, 1796; Tazewell, July 22, 2386; Champaign, Aug. 13, 1041; Piatt, Aug. 17, 1128; McHenry, Aug. 22, 1205; Lee, Sept. 8, 5719; LaSalle, June 19, 5236, Sept. 12, 1477; JoDaviess, Sept. 18, 5985; Rock Island, Sept. 21, 1611; Union, Oct. 21, 1932, Oct. 25, 1993 and 2004; Pulaski, Nov. 4, 2249.

In the specimens on *Ambrosia* the spores are somewhat thinner walled and more rounded than in those on *Xanthium*, but the difference is slight.

P. tanaceti, DC.

II., III. Amphigenous. Sori mostly rather large, scattered, often sprinkled over the entire leaf; uredospores globose to ovate, echinulate, 21–24 by 27–32 μ; teleutospores variable, broadly oblong to broadly oval with rounded ends, usually little constricted, smooth, or sometimes warty towards the apex, the latter thickened or not, 21–27 by 34–60 μ; pedicel hyaline, very long, two to four times the length of the spore.

On leaves of *Helianthus annuus:* Piatt, Aug. 10, 1006; Lake, Aug. 22, 1206, I., II.; Kane, Aug. 30, 1366, I., II.; Cook, Sept. 8, 1468, I., II.; Rock Island, Sept. 27, 1601. *H. rigidus:* McLean, July 26, 2297, Oct. 11, 1831; Piatt, Aug. 10, 1004; LaSalle, Sept. 12, 1491, Sept. 14, 1539, Sept. 16, 1557, Sept. 20, 1598. *H. mollis:* Marion, Oct. 20, 1902. *H. decapetalus:* McLean, Aug. 4, 2299, Oct. 6, 1799. *Helianthus sps.:* Adams, June 30, 5361, II.; McLean, July 15, 2301, July 29, 2300, II., III., Oct. 6, 1798, Oct. 7, 1822, Oct. 11, 1837, Oct. 18, 1871; Champaign, Aug. 13, 1038; Piatt, Aug. 17, 1129; McHenry, Sept. 20, 1160; Kane, Aug. 30, 1365; Cook, Sept. 5, 1437; Lee, Sept. 11, 5784; LaSalle, Sept. 13, 1496, Sept. 14, 1541, Sept. 17, 1565; Stephenson, Sept. 13, 5835, II., III., 5844, II., III.; JoDaviess, Sept. 15, 5916, II., III.; Ogle, Sept. 23, 6146, III.; Rock Island, Sept. 21, 1612, II., III., Sept. 26, 1665, Sept. 27, 1675; Henry, Sept. 28, 1723; Fulton, Oct. 1, 1766, Oct. 3, 1738; Jersey, Oct. 13, 6291; Union, Oct. 21, 1904, Oct. 28, 2097.

Var. **Vernoniæ.**

Amphigenous; spots small, purple, with a pale yellow border, or yellow only, sometimes indistinct; sori scattered, subrotund, prominent, blackish brown or black; spores oblong-elliptical, mostly regularly rounded at the ends, slightly constricted, a central nucleus in each cell, 20 by 42 μ; pedicel hyaline, about four times as long as the spore. Uredospores preceding or accompanying the teleutospores, not numerous, subglobose, sharply echinulate, about 25 μ in diameter.

On *Vernonia fasciculata:* Champaign, Aug. 11, 1014; Piatt, Aug. 16, 1094, Aug. 17, 1098, 1102; McLean, Sept. 6, 5670, Oct. 12, 1844, 1850; LaSalle, Sept. 14, 1527, Sept. 30, 6254; JoDaviess, Sept. 19, 5996.

Schweinitz (N. Am. Fungi, No. 2926) calls this form *P. Vernoniæ*, and describes it as follows:

> "Spots none. Differing from *P. helianthi* in the rather large pulvinate sori, and the delicate ferruginous color of the spores. It sometimes occurs also on species of Helianthus."

But the gradation of forms between this and the typical *P. helianthi* leaves no sufficient ground for *specific* distinction. Further, *P. helianthi* seems to be *P. tanaceti*, DC. Winter (Rabh. Krypt., Fl. I., p. 209) unites the two, while Schröter (Hedw. XIV., p. 180) maintains that they are distinct, basing his arguments on distribution. The size, shape, and color of the spores vary greatly, but are so connected by intermediate forms that no specific distinction can be founded on these characteristics. Cultures are necessary to determine such distinction if there is any. In the meantime, so long as we are unable to recognize a difference by appearance, there can be no question as to which name to choose, even though this carries us against common usage and our own habit.

P. flosculosorum, (Alb. & Schw.) Roehl.

II., III. Amphigenous. Sori small, scattered or in small clusters. Uredospores subglobose, sharply echinulate, mostly rather thick walled, 24–30 μ; teleutospores broadly elliptical or oval, constriction little or none, rarely thickened at the apex,

usually furnished with punctiform to wart-like projections, 18–25 by 30–45 μ; pedicels hyaline, fragile, not usually longer than the spore.

Uredo flosculosorum, Alb. & Schw. Uredo black, sori scattered, minute, subrotund, pulvinate, powder rather loose, spores unequal, subcaudate.—Albertini and Schweinitz, Conspect. Fung. p. 128.

On *Cirsium discolor:* Adams, July 6, 5425, II. *C. lanceolatum:* LaSalle, June 19, 5237, II., Sept. 29, 6241, II., III.; Tazewell, July 22, 2410, II., Lee, Sept. 8, 5718, II.: Stephenson, Sept. 14, 5890, II.; JoDaviess, Sept. 18, 5986, II., III.; Rock Island, Sept. 21, 1608, II., III., Sept. 24, 1645, II., III., Sept. 26, 1663, II., III., Sept. 27, 1674, II., III.; Ogle, Sept. 23, 6149, II.; Fulton, Oct. 1, 1770, II., III., McLean, Oct. 6, 1794, II., III., Oct. 12, 1841, II., III., 1843, II., III., Oct. 13, 1858, II., III., Oct. 18, 1890, II., III.; Champaign, Nov. 9, 2389, II., III., Nov. 12, 2390. *Taraxacum dens-leonis:* McLean, May 25, 4776, II., May 20, 4828, II., July 6, 2391, II., July 16, 2392, II., July 25, 2393, II., Oct. 11, 1835, II.; Champaign, June 8, 4902, II., Nov. 7, 2277, II., III.; LaSalle, June 19, 5229, II., Sept. 14, 1540; Adams, July 7, 5447, II., July 11, 5501, II.; McHenry, Aug. 22, 1218, II.; Boone, Sept. 2, 1419, II.; Stephenson, Sept. 13, 5828, II.; Rock Island, Sept. 21, 1613, II., Sept. 24, 1653, II. *Hieracium Canadense:* McHenry, Aug. 20, 1197; Boone, Sept. 2, 1426; Stephenson, Sept. 13, 5833, II., III.; Ogle, Sept. 23, 6130, II., III.; LaSalle, Sept. 30, 6256, II., III.

Under this species are included the forms that have been known on *Cirsium* as *P. cirsii*, Lasch., and *P. compositarum*, Schl., on *Taraxacum* as *P. variabilis*, Grev., and on *Hieracium* as *P. hieracii*, Mart. The teleutospores of American specimens are very minutely warty, or apparently smooth, agreeing with Winter's remarks on this species in Hedwigia, XIX., p. 20. Nearly or quite all the specimens on *Cirsium* (except No. 2410) present both uredo- and teleutoforms, but on *Taraxacum* teleutospores are found only in specimens collected late in the season (No. 2277).

P. maculosa, Schw.

III. Amphigenous. Sori scattered or regularly collected in definite circinate clusters, often appearing on both sides of the leaf over the same area, cinnamon-brown; spores clavate-oblong, thin walled, fragile, smooth, much constricted, upper segment widest, apex thickened, rounded or variously pointed, base narrowed to the pedicel, 15–18 by 30–45 μ; pedicel hyaline, usually less in length than the spore.

On *Cynthia Virginica:* Johnson, May 16, 4709.

Schweinitz (Syn. Fungi Am. Bor., p. 295, No. 2922,) refers this species to *P. maculosa*, Strauss; but the latter is *P. prenanthis* (Schum.), and is very different from the present species.

P. lobeliæ, Gerard.

III. Mostly hypophyllous. Sori small, scattered or irregularly and rather loosely clustered, cinnamon-brown; spores oblong, smooth, thin walled, very deeply constricted, fragile, segments equal, or the lower narrower, 15–18 by 30–39 μ; pedicel very fragile, shorter than the spore.

Sori minute, scattered or confluent, tawny brown; spores oblong-elliptical, slightly constricted at the septum and easily separating into two parts, pale, .0013–.0016 in. long; pedicel short or obsolete.—Peck, XXVI. Rep. N. Y. Mus., p. 77.

On *Lobelia syphilitica:* Adams, July 7, 5444; McLean, Aug. 6, 2303, Sept. 6, 5669; LaSalle, Sept. 13, 1517, Sept. 17, 1566; JoDaviess, Sept. 20, 6026. *L. puberula:* Johnson, May 13, 4710; Union, Aug. 18.

This is *P. microsperma*, B. & C. in Grevillea III., p. 55. The sori are usually more densely aggregated on *L. puberula*, but there is no other difference.

P. seymeriæ, Burrill.

III. Hypophyllous, and on stems and calyces. Spots definite, dark-colored; sori rather large, mostly crowded in conspicuous circular clusters a fifth of an inch in diameter, these sometimes confluent, dark brown; spores elliptical or oval, little constricted, obtusely rounded at the ends, smooth, wall firm, brown, 15–21 by 30–36 μ; pedicel hyaline, broad, persistent, twice as long as the spore.

On *Seymeria macrophylla:* McLean, July 29, 2304, 2305, Sept. 2; Champaign, July 31; Union, Aug. 16.

This is perhaps near *P. veronicæ* (Schum.), from which it differs in the size of the sori, the shape of the spores, and especially in the stout persistent pedicels. In the form of *P. veronicæ* with persistent pedicels, the spores are oblong to spindle-form, as well as furnished with a thickened apex.

P. lateripes, B. & R.

II., III. Amphigenous. Sori usually small, round or angular, scattered, or sometimes irregularly clustered; uredospores subglobose, strongly echinulate, 16–21 by 21–24 μ; teleutospores broadly oval, little constricted, ends rounded, segments nearly equal, surface minutely roughened, 20–22 by 25–32 μ; pedicel hyaline, once to twice the length of the spore, usually more or less laterally produced.

Spots yellow or quite obsolete; sori scattered; spores short, obtuse at either end, almost horizontal, with a long, lateral, flexuous stem.—Berkeley, Grevillea III., p. 52.

On *Ruellia ciliosa:* Lee, Sept. 9, 5762; Rock Island, Sept. 26, 1662; Ogle, Sept. 26, 6183; Jersey, Oct. 12, 6269; Union, Oct. 22, 1958, II., III. *R. strepens:* LaSalle, Sept. 14, 1529; Jersey, Oct. 13, 6292, Oct. 14, 6310; Union, Oct. 31, 2150, II., III.; Champaign, Oct. 31, 6378.

This occurs on both sides of the leaf and also on the stem. Uredospores occur sparingly among the teleutospores. Those on *R. ciliosa* are globose, slightly echinulate, 22 μ in diameter; and the teleutospores 21–22 by 30–32 μ. The pedicels attain a length of 35 μ, but are easily broken. The uredospores on *R. strepens* are subglobose, 16–18 by 21 μ; the teleutospores are smaller, darker colored and firmer, and the pedicel longer and less easily broken, size 19–21 by 25–28 μ; and the pedicels reach a length of 75 μ.

P. menthæ, Pers.

I. Æcidia irregularly clustered upon dark-colored more or less swollen spots on the leaves and stems, round, or on the

latter usually much elongated and often confluent, erect, short, irregularly split, not recurved; spores elliptical or ovate-oblong, minutely echinulate, 15–18 by 22–28 μ.

II., III. Hypogenous. Spots yellow or brown, often conspicuous, frequently confluent; sori scattered, round, rather large, uredosori yellowish brown, flat, teleutosori blackish, prominent; uredospores subglobose or ovate, minutely echinulate, thin walled, about 18–21 by 21–24 μ; teleutospores short, broadly ovate or broadly oval, somewhat constricted, ends rounded, furnished with a short, obtuse, almost hyaline, apiculus, surface beset with minute warts, 21–27 μ; pedicel hyaline, once to twice length of spore.

Scattered, punctiform, obscurely spadiceous, spores subquadrangular; pedicel very short.—Persoon Syn. Fung., p. 227.

On leaves of *Mentha Canadensis:* Ogle, Sept. 25, 6169, II., III. *Mentha sps :* Lee, Sept. 27, 6206, II., III. *Cunila Mariana:* Johnson, May 11, 4620, I., II., May 12, 4652, II., May 15, 4690, I., II., III., May 16, 4707, II., 4711, II., III., Jersey, Oct. 12, 6268, II., III., Oct. 13, 6293, II., III.; Union, Oct. 25, 2009, II., III. *Pycnanthemum pilosum:* Adams, July 6, 5436, II., July 7, 5446, II. *P. lanceolatum:* McHenry, Aug. 20, 1163, II., III.; Stephenson, Sept. 13, 5837, II., III.; JoDaviess, Sept. 15, 5918, II., III. *P. linifolium:* Jersey, Oct. 12, 6267, II., III. *Monarda fistulosa:* Johnson, May 12, 4653, II., May 15, 4691, II.; Adams, June 28, 5322, II., June 30, 5369, II., III., July 5, 5419, II., III.; McLean, July 11, 2394, II., July 15, 2395, II., July 16, 2396, II., July 17, 5578, II., III.; McHenry, Aug. 20, 1180, II., III., Aug. 24, 1285, II., III.; Lake, Aug. 27, 1357, II., III., Aug. 29, 1367, II., III.; Lee, Sept. 8, 5722, II., III.; Stephenson, Sept. 13, 5799, II., III.; Rock Island, Sept. 21, 1610, II., III., Sept. 26, 1664, II., III., Sept. 27, 1672; Fulton, Oct. 1, 1769, II., III.; Jersey, Oct. 12, 6265, II., III.; Champaign, Nov. 7, 2276. *M. Bradburiana:* Johnson, May 11, 4619, II.; Jersey, Oct. 18, 6294, II., III. *M. punctata:* Cook, Sept. 3, II., III., coll. J. C. Arthur; Lee, Sept. 11, 5782, II. *Blephilia hirsuta:* Pulaski, May 2, 4443, II., May 5, 4494, II., Johnson, May 11, 4618, II.; Adams, June 28, 5323, II.; Mc-

Lean, July 20, 2494, II., 5604, II., Aug. 1, 2493, II., Aug. 6, 2495, II., Oct. 18, 1876, II., Oct. 19, 1895, II., Stephenson, Sept. 21, 6065, II., III.

The aecidium form is not usually present, but occurs on the same host with II. and III., both of which are abundant.

The American form differs from the European in having the teleutospores echinulate, and has been called var. *Americana*. On *Blephilia hirsuta* the parasite is plainly different from the type. The sori more frequently have a circular arrangement around one evidently older, the epidermis is later rupturing, and afterwards is less apparent as a border; the spores are much lighter colored, and the epispore is thinner. This is the uredoform. The teleutospores seem to be rarely developed.

P. glechomatis, DC.

III. Hypogenous; spots small, distinct, at first light yellow, soon becoming blackish and breaking out, leaving more or less circular holes; sori usually closely clustered, often somewhat circinating, rarely scattered, ferruginous brown; spores subelliptical, very variable, sometimes obtusely rounded, but often conspicuously pointed above or below, oblong-elliptical, light-colored, 13 by 31 μ; pedicel hyaline, fragile, nearly as long as the spore.

P. hyssopi, Schw. Spots lutescent, effuse; sori aggregated, compact, tawny, somewhat circinate and undulately confluent, at first blackish, small, but occurring copiously on the leaves. Spores tawny, becoming loose.—Schweinitz, N. Am. Fungi, No. 2944, p. 296.

On leaves of *Lophanthus nepetoides*: Kane, Aug. 30, 1370, 1383; Lee, Sept. 8, 5721; Stephenson, Sept. 13, 5829.

This is *P. glechomae*, DC. (Fl. Fr., VI, p. 55), and *P. hyssopi*, Schw.

P. plumbaria, Peck.

III. Amphigenous. Sori scattered on stems and leaves, small or large, sometimes confluent, covered until late with the more or less fissured and peculiar lead-colored epidermis, when naked dark reddish brown, powdery; spores irregular, broad,

mostly broadly ovate, obovate or elliptical, little constricted, apex usually slightly thickened or apiculate, smooth or minutely roughened, 21–25 by 32–50 μ, commonly about 39 μ long; pedicel hyaline, rather fragile, from less than one to one and a half times the length of the spore, sometimes more or less lateral.

Spots brown and indefinite, sometimes none; sori mostly hypophyllous, sometimes amphigenous, orbicular, oblong or irregular, scattered or crowded, sometimes confluent, prominent, at first covered by the epidermis and then of a peculiar lead-color, blackish when exposed; spores obovate or elliptical, obtuse, slightly constricted at the septum, minutely rough, .0012–.0016 of an inch long, .0008–.001 of an inch broad, the pedicel very short, colorless.—Peck, Bot. Gaz., Vol, VI., p. 228.

On *Phlox divaricata:* Adams, June 30, 5358.

The description by Peck is from specimens collected in Utah. During the same year, but believed to be later, DeThümen sent out Century XXI of his Mycotheca Universalis, containing, with No. 32, a description, with specimens from Idaho, on *Gilia*, under the name of *P. Wilcoxiana.* By comparison of authentic specimens these prove to be specifically indistinguishable, as well as those of Ellis' North American Fungi, No. 1044—however, the latter bears the varietal name of *phlogina.* This last has a different nuclear spot in each segment, and the epispore is more distinctly roughened. The Illinois specimens on *Phlox* are very nearly smooth, and do not have this round segmental spot, hence are more like the typical specimens of Peck in these respects. They are somewhat more irregular in shape than any of the others, and the pedicel more often obliquely produced.

P. convolvuli, Cast.

I. Hypogenous. Spots small, distinct, or sparingly confluent, brown; æcidia irregularly clustered or sometimes subcircinate, short, small, pseudoperidium fragile, becoming powdery soon after opening, spores subglobose or elliptical, epispore thin, tuberculate, 16–18 by 18–25 μ; spermagonia few, central, above. (*Æcidium calystegiæ*, Desm., *Æ. dubium*, Clint.)

II., III. Amphigenous, more common beneath; sori rounded or angular, long covered by the epidermis; uredosori

light brown, naked teleutosori black; uredospores subglobose, finely echinulate, 18–21 by 21–30 μ; teleutospores clavate-obovate, constricted, obtusely rounded above, but sometimes having a thickened and angular apex, narrowed below to the thick pedicel, smooth, 22–27 by 42–54 μ; pedicel stout, colored, shorter than spore.

On leaves of *Calystegia sepium:* Champaign, June 8, 4914, I., Aug. 11, 1013, II., III.; LaSalle, June 21, 5254, I., II., Sept. 12, 1486, II., III., Sept. 16, 1556, II., Sept. 17, 1564; Fulton, I., coll. J. Wolf; McLean, July 6, 2452, II., July 7, 2398, II., July 12, 2400, II., July 15, 5561, II., III., July 20, 2397, II., July 25, 2399, II., 2401, II., Aug. 1, 2403, II., Oct. 6, 1795, II., III.; Piatt, Aug. 17, 1101, II.; McHenry, Aug. 28, 1248, II.; Lake, Aug. 29, 1362, II.; Kane, Aug. 30, 1372; Boone, Sept. 2, 1424; Lee, Sept. 8, 5717, II., III., Sept. 9, 5764, II., III.; JoDaviess, Sept. 18, 5984, II., III.; Ogle, Sept. 22, 6110, II., III.; Rock Island, Sept. 24, 1652, II., III., Sept. 27, 1677.

While covered by the epidermis the sori have a livid hue, and this condition usually lasts some time.

P. gentianæ, (Strauss) Lk.

II., III. Epiphyllous or amphigenous. Spots none; sori scattered, often rather large, long or even persistently covered by the epidermis; uredospores subglobose or oval, sharply echinulate, thick walled, rather dark brown, 18–24 by 21–27 μ; teleutospores very broadly oval, sometimes almost subglobose, little constricted, apex slightly thickened or somewhat apiculate, each segment often showing a small nuclear spot, smooth, 21–30 by 30–37 μ; pedicel hyaline, fragile, usually crooked, about twice the length of the spore.

On *Gentiana puberula:* Lee, Sept. 11, 5786, II., III.; Sept. 27, 6202, II., III.

The teleutospores are quite often single celled.

P. polygoni-amphibii, Pers.

II., III. Amphigenous. Sori small, round or angular, in a circle about a larger sorus, or irregularly collected in small clusters, long covered by the epidermis, often very numerous;

uredospores subglobose or oval, sharply echinulate, 18–22 by 21–27 μ; teleutospores clavate or clavate-obovate, constricted, apex more or less strongly thickened, truncate, obtuse or variously pointed, narrowed below to the rather thick pedicel, smooth, wall rather thin, 12–21 by 33–54 μ; pedicel somewhat colored, short, half the length of the spore.

Opaque, spadiceous, depressed, spores oblong-ovate, narrowed into a slender pedicel.—Persoon, Syn. Fung., p. 227.

On leaves of *Polygonum amphibium*: Champaign, July 24; McHenry, Aug. 25, 1291, II., III., Aug. 26, 1314, II., 1331, 2404, II., III.; Lake, Aug. 27, 1344, II., III., 1347, II.; Kane, Aug. 30, 1371; Cook, Sept. 5, 1439; Lee, Sept. 9, 5758, II., III.; Stephenson, Sept. 13, 5800, II., III., Sept. 21, 6062, II., III., 6063, II., III.; LaSalle, Sept. 16, 1560, Sept. 19, 1593, Sept. 28, 6224, II., III.; JoDaviess, Sept. 20, 6013, II., III., 6014, II., III.; Ogle, Sept. 22, 6111, II., III.; Henry, Sept. 28, 1703, II., III.; Fulton, Oct. 1, 1788. *P. Virginianum*: Rock Island, Sept. 26; Adams, July 14, coll. C. A. Hart.

The pedicels of the uredospores are long, and appear in the sori of both states like paraphyses, but the teleutosorus not following in a uredo sorus has none of them.

There is some question about the identity of the *Puccinia* on *Polygonum Virginianum*. The sori are similar, but the teleutospores are more irregular in shape, the apex more commonly truncate, the epispore thinner, and the cell contents of different appearance. But there does not seem to be sufficient reason to separate this as a species or even named variety.

Uredoforms have been collected on *Polygonum acre* and *P. Pennsylvanicum*, without, however, the teleutoform. On the former host the appearance is much like those described, but on the latter the pedicels of the spores are stronger and more persistent.

P. aletridis, B. & C.

II., III. Amphigenous. Sori rather small, scattered, often very numerous; uredosori somewhat prominent, powdery, cinnamon-brown, teleutosori little raised, long covered by the epidermis, blackish; uredospores subglobose or oval, sharply echinulate, wall thick, 18–24 by 21–27 μ; teleutospores clavate, ob-

long or elliptical, abruptly and rather deeply constricted, apex thickened and mostly narrowed to a rounded point, lower segment usually longer and narrowed to the pedicel, surface smooth, 12–21 by 30–50 μ; pedicel hyaline, usually less than the length of the spore, but sometimes longer.

On *Aletris farinosa:* Millers, Indiana, near the Illinois line, July 4, 5592, II., E. J. Hill. It probably occurs in Illinois.

P. smilacis, Schw.

II., III. Hypogenous. Spots small, numerous, brick-red; sori scattered or irregularly circinate, punctiform or elongated, surrounded by the ruptured epidermis, and by a row of short club-shaped paraphyses. II. Spores oval, slightly echinulate, pale, 21–27 μ, on fragile pedicels. III. Spores broadly elliptical, conspicuously constricted, upper segment considerably rounded or obtusely pointed, often narrowing below to the pedicel, dark colored, smooth, 21 by 36–42 μ; pedicel thick, tinted, as long as the lower segment.

On leaves of *Smilax hispida:* Union, Oct. 24, 1968, II., III., Oct. 29, 2120, II., Nov. 4, 2275, II., III.; Pulaski, Nov. 4, 2238, II., III.

P. caricis, (Schum.) Rebent.

II., III. Hypogenous. Sori more or less elongated, variable, scattered, often very numerous and conspicuous, the ruptured epidermis ragged and long adherent, uredosori cinnamon-brown, teleutosori black; uredospores globose, subglobose, or sometimes elongated, conspicuously but not sharply echinulate, 18–24 by 21–27 μ; teleutospores cuneate, little constricted, much thickened and obtusely rounded or almost truncate above, and narrowed to the pedicel, smooth, 15–20 by 33–45; pedicel hyaline or nearly so, one half to once the length of the spore.

On *Carex sps.:* Union, April 17, 4141, II.; Pulaski, May 1, 4405, II., 4406, II., May 2, 4447, II., May 5, 4511, II.; Champaign, June 10, 4960, II.; Adams, June 27, 5311, II., July 11, 5504, II.; McLean, July 15, 2327, II., July 20, 5603, II., III., Aug. 1, 2325, Aug. 4, 2326, Aug. 6, 2413, Sept. 6, 5667,

II., III., Oct. 19, 1893, II., III.; McHenry, Aug. 20, 1158, Aug. 23, 1252, Aug. 26, 1327, 1328; Kane, Aug. 30, 1369, II., III.; JoDaviess, Sept. 15, 5921, II., III., Sept. 16, 5956, II., III.; Ogle, Sept. 22, 6115, II., III.; Rock Island, Sept. 24, 1646, Sept. 27, 1676, 1680; Fulton, Oct. 3, 1733. *Dulichium spathaceum:* McHenry, Aug. 25, 1311; Cook, Sept. 5, 1438, Sept. 8, 1467, II., III.

Uredo Caricis, Schum. (Enum. Plant. Saell. II. [1803], p. 231), *Puccinia caricis*, Rebent. Fl. Neom. [1804], *P. caricina*, DC. (Fl. Franc. VI. [1815], p. 60).

On *Dulichium spathaceum* the uredospores are smaller and often elliptical to oblong, 12–15 by 15–21 μ; the teleutospores are variable, more often truncate.

P. obtecta, Peck.

II., III. Amphigenous. Sori scattered or irregularly clustered, often crowded, oblong or more or less circular, long covered by the epidermis, which at length becomes simply cracked or raggedly torn; uredospores elliptical or obovate-oblong, wall rather thick, minutely echinulate, pedicel rather persistent, 15–20 by 21–30 μ; teleutospores elliptical, somewhat constricted, apex thickened, obtusely rounded or variously produced and pointed, usually narrowed below, often without septum, smooth, 18–20 by 45–60 μ; pedicel short, not usually more than half the length of the spore, deeply tinted.

On *Scirpus validus:* McLean, July; Fulton, coll. J. Wolf.

P. angustata, Peck.

II., III. Hypogenous. Sori oblong or linear, often arranged in long parallel rows or confluent in long lines, blackish, the remains of the ruptured epidermis persistent; uredospores subglobose to elliptical, thin walled, sharply echinulate, 16–21 by 21–30 μ; teleutospores narrow, clavate or elongate-parallel, somewhat constricted, apex much thickened, often beak-like, narrowed below to and with the pedicel, 15–21 by 45–60 μ; pedicel colored, less than one half to once the length of the spore.

Hypogenous; spots pallid or none; sori oblong or linear, sometimes regularly arranged at equal intervals in long parallel lines, narrow, surrounded by the ruptured epidermis, black; spores narrow, oblong-clavate or elongated, septate above the middle, strongly constricted, having the lower cell more narrow than the upper, and cylindrical or slightly tapering downwards, .0018-.0024 in. long, ·0006 in. broad; peduncle colored, thick, very short.—Peck, XXV. Rep. N. Y. Mus., p. 123.

On leaves of *Scirpus atrovirens:* Piatt, Aug. 16, 1093; Cook, Sept. 5, 1451.

P. windsoriæ, Schw.

II., III. Hypogenous, occasionally somewhat amphigenous. Sori small, little elevated, irregularly scattered, very numerous, sparingly confluent, linear or oblong, soon naked, the ruptured epidermis scarcely evident; uredospores subglobose or obovate, epispore medium thick, sharply echinulate, rather deep brown, 18–24 μ; teleutospores broadly elliptical or obovate, slightly or not at all constricted at the septum, mostly obtusely rounded at the ends, upper segment mostly larger, vertex slightly thickened, smooth, 18–21 by 27–39 μ; pedicel about the length of the spore or shorter, stout, rather deeply colored.

On *Muhlenbergia:* Stephenson, Sept. 13, 5834, II., III.

P. graminis, Pers.

I. Hypogenous. Spots definite, usually small, purple, somewhat thickened; æcidia irregularly crowded, or sometimes circinate, short, border narrow, numerously lacerated, little recurved; spores subglobose or angular, epispore thin, minutely tuberculate, contents fine-granular, 11–15 μ; spermagonia minute, clustered, not usually numerous, opposite the æcidia.

II. Amphigenous. Sori linear, on the leaves short and scattered, on the leaf-sheaths often confluent in long lines, orange-yellow; spores narrowly obovate or elliptical, epispore thick, strongly echinulate, 18–21 by 27–36 μ.

III. Sori linear to elliptical, often confluent in long lines, mostly on the leaf-sheaths, rather prominent, soon naked, black; spores clavate or narrowly elliptical, mostly somewhat constricted, vertex strongly thickened, often pointed but some-

times rounded, narrowed below to the pedicel, smooth, chestnut-brown, 15–21 by 36–60 μ; pedicel firm, colored, about the length of the spore, sometimes shorter.

Sori, dense, linear, blackish, spores subturbinate, constricted in the middle.—Persoon, Syn. Fung., p. 228.

On culms, sheaths and leaves of cereals and grasses. On *wheat:* McLean, July 11, 2335 and 2343, July 12, 2341, July 15, 2339; Tazewell, July 22, 2340; Piatt, Aug. 17, 1134; McHenry, Aug. 20, 1145, Aug. 22, 1224; Fulton, Oct. 1, 1773. *Oats:* McLean, July 11, 2334, July 12, 2332 and 2333; Tazewell, July 22, 2329, 2330 and 2331; Champaign, Aug. 13, 1029 and 1033; Piatt, Aug. 15, 1063; McHenry, Aug. 20, 1144, Aug. 26, 1323; Fulton, Oct. 1, 1774. *Agrostis vulgaris:* McHenry, Aug. 24, 1275, Aug. 26, 1324; LaSalle, Sept. 13, 1521; JoDaviess, Sept. 18, 5987; Rock Island, Sept. 27, 1673; Fulton, Oct. 3, 1732; McLean, Oct. 4, 1760; Union, Oct. 21, 1905. *Hordeum jubatum:* McLean, July 11, 2346, July 17, 5580, II., III.; July 19, 5593, II., III.; McHenry, Aug. 23, 1231, Aug. 25, 1307, Aug. 26, 1316, Aug. 31, 1392; Rock Island, Sept. 26, 1661.

As here identified a variable species, though some forms often formerly included are specifically separated under the names *P. emaculata*, *P. windsoriæ*, and *P. andropogi*. The description is made from specimens on wheat. On *Agrostis* the teleutospores are sometimes nearly typical (No. 1732), in other cases they vary much in shape and thickness ofthe epispore—shorter, rounder and thinner for the most part on Nos. 1275, 1603, and especially 1905. The uredo is very characteristic in all.

P. phragmites, (Schum.) Kornicke.

II., III. Amphigenous. Sori scattered, very prominent, mostly rather large, elliptical, somewhat powdery, soon naked, the remains of the ruptured epidermis not usually visible; uredospores elliptical, epispore very thick, strongly tuberculate, without paraphyses, 18–21 by 27–32 μ; teleutospores elliptical or oblong, somewhat but not abruptly constricted, vertex a little thickened and rounded or obtusely pointed, smooth, pale brown, 18–22 by 37–60 μ; pedicel very long, three to four times

the length of the spore, rather slender but firm, slightly tinted.

On *Spartina cynosuroides:* McLean, July 20, 2348, Oct. 11, 1829; Lake, Aug. 27, 1346; Fulton, Oct. 1, 1771. *Phragmites communis:* McHenry, Aug. 26, 1325; Kane, Aug. 30, 1368. *Andropogon furcatus:* Rock Island, Sept. 24, 1648. *A. scoparius:* JoDaviess, Sept. 15, 5920.

This species was first described as *Uredo Phragmitis* by Schumacher (Enum. Plant. Saell. II. [1803] p. 231), and his description shows that his Uredo was that of this species, if, indeed, he had not the teleutoform. Hedwig next described it as *Puccinia arundinacea*, which description was published by DeCandolle, together with one of his own, in Lam. Encyc. bot. (1806) p. 250; it is thus explained why DC. is sometimes written as authority for this name instead of Hedw. Schweinitz (Syn. Fung. Car. [1822] No. 487) published it under the name of *Puccinia arundinariæ*.

The Illinois specimens on *Phragmites communis* have teleutospores narrower and more constricted, so that the segments are each nearly elliptical, while the European specimens on same host (Rabh. Herb. Mycol. 282) are much like the Illinois specimens on *Spartina cynosuroides* and on *Andropogon*. But the spores on one *Spartina* plant closely resembles the Illinois *phragmites* form.

P. rubigo-vera, (DC.) Winter.

II., III. Amphigenous. Uredosori mostly hypogenous, linear or oblong, irregularly scattered, seldom confluent, somewhat elevated, soon open; teleutosori linear or oblong, scattered or variously confluent, long covered by the unbroken epidermis, black, surrounded by a dense row of dark-brown paraphyses; uredospores subglobose, epispore rather thin, minutely echinulate, 21–25 μ; teleutospores cuneiform, oblong or elliptical, constricted or not at the septum, but usually tapering below, vertex thickened, truncate, obtusely rounded or sometimes more or less pointed, epispore thin, smooth, cell contents granular, 12–18 by 27–54 μ; pedicel short, rarely half the length of the spore, deeply tinted.

On *wheat:* Adams, June 26, 5294, June 29, 5344, July 6, 5426, II., III.; McLean, July 11, 2343, July 17, 5583, II., III.;

McHenry, Aug. 22, 1224. *Oats:*— *Rye:* LaSalle, June 19, 5225, II., III. *Elymus Virginicus:* Champaign, Aug. 11, 1022; McHenry, Aug. 24, 1276; Ogle, Sept. 25, 6155, II., III.

This name is founded upon the recognition of the uredoform as *Uredo rubigo-vera*, DC. (Flore Franc. VI. [1815] p. 83), which to say the least is doubtful. The same name has been used for the uredoform of *Puccinia coronata*, and of *Puccinia graminis*, found on the same host species, and doubtless equally included by DeCandolle in his supposed species. Winter (Die Pilze, p. 217) probably had good reasons for accepting the name as here given, but should, for any reason, botanists decline to follow him in this, then *Puccinia striaeformis*, Westd. (Bull. de l' Acad. Belg. [1853] XXI.), rather than *Puccinia straminis*, Fuckel (Enumer. Fung. in Jahr. Ver. f. Natur v. Nassau [1861, etc.]), should be adopted, though the latter recognizes DeCandolle's *Uredo rubigo-vera* as the early stage of the teleutoform named by him. Certain it is that *P. coronata* and *P. rubigo-vera* are very closely allied.

P. coronata, Corda.

II., III. Amphigenous. Uredospores subglobose, echinulate, 18–21 by 21–24 μ; teleutosori small, oblong or linear, slightly raised, surrounded by a dense row of paraphyses, long covered by the epidermis; teleutospores cuneate, scarcely constricted at the septum, more or less truncate above, crowned with one to several conspicuous, obtuse, horn-like projections, epispore thin, smooth, cell contents granular, 15–18 by 45–55 μ; pedicel short, less than half the length of the spore, rather fragile.

Sori linear, short, minute, obscurely fuscous, covered by the pallescent epidermis; spores subsessile, subclavate, crowned at the apex with acute, stellate, radiate, flame-yellow teeth, yellow below. Length of spore .00175 in.—Corda, Icon. I, p. 6.

On leaves and sheaths of *oats:* Adams, June 30, 5360, II., III., July 10, 5456, II., III., July 11, 5502, II., III.; McLean, July 11, 2334, Sept. 6, 5665, II., III.; Tazewell, July 22, 2330 and 2331; McHenry, Aug. 20, 1144. *Wheat:* Fulton, Oct. 1, 1767, II., III.

This species is certainly closely related to *Puccinia rubigovera*. Indeed, it is scarcely possible to separate them, except by the terminal projections of the teleutospores in *P. coronata*, and these are present in varying degrees, sometimes (as in No. 2334) nearly wanting.

P. emaculata, Schw.

II., III. Mostly epigenous, sometimes amphigenous. Sori small, rather prominent, mostly very numerous, irregularly scattered or crowded, rarely confluent on the leaves, but on the sheaths forming long, irregular lines, black, rather early erumpent but long surrounded by the ruptured epidermis; uredospores subglobose, epispore rather thin, sharply but minutely echinulate, 15–24 μ; teleutospores elliptical or broadly clavate, slightly constricted, vertex strongly thickened and obtusely pointed or rounded, narrowed below, smooth, not deeply colored, 15–21 by 30–48 μ; pedicel once to once and a half as long as the spore, tinted.

Entirely without spots; at first sori entirely covered or sparingly erumpent, then often confluent, minute, abbreviated, narrow, parallel, often acuminate at both ends. Spores black, rather small, when immersed in water fuscescent. Everywhere on species of *Panicum*, especially *P. pubescens* in fields.—Schweinitz, N. Am. Fung., No. 2912, p. 295.

On *Tricuspis seslerioides:* Union, Nov. 4, 2274. *Eragrostis pectinacea:* Union, Oct. 21, 1903. *Panicum capillare:* LaSalle, Sept. 14, 1537, II., Sept. 29, 6238; Rock Island, Sept. 21, 1609, Sept. 23, 1628, Sept. 26, 1661, Sept. 27, 1679; JoDaviess, Sept. 19, 5993; Stephenson, Sept. 21, 6059; Ogle, Sept. 23, 6142, II., III.; Fulton, Oct. 1, 1768. *P. virgatum:* Lee, Sept. 9, 5760; Ogle, Sept. 22, 6109; Rock Island, Sept. 27, 1695.

On *Panicum virgatum* the teleutospores have in each segment a small circular nuclear spot, and the pedicels are nearly colorless. On *Tricuspis seslerioides* (No. 2274) and *Eragrostis pectinacea* (No. 1903) the sori are mostly hypophyllous, and the teleutospores are often lighter colored, with hyaline pedicels.

P. flaccida, B. & Br.

II., III. Amphigenous. Sori small, oblong to linear, often confluent, at length rupturing the epidermis, reddish-ferruginous. Uredospores vary from elliptical to subglobose, the latter about 25 μ, furnished with two or more hyaline points (germinal pores?), sharply echinulate, cinnamon-colored. Teleutospores exceedingly variable, often undivided, the septum, when present, transverse, oblique or longitudinal, equally, or in every degree unequally, dividing the spore. The simple ones are usually clavate, the divided ones vary from clavate to spheroidal, regularly formed or much constricted, and lobed with one or two thickened apical points, length about 30–40μ, lighter colored than the uredo; pedicel hyaline, once or twice the length of the spore.

Sori small, short; spores flaccid, with a long hyaline pedicel, obtuse, contracted in the middle.—Berkeley, Jour. Linn. Soc., Vol. XIV., p. 91.

On *Panicum crus-galli:* Henry and Rock Island, Sept. 28, 1701, II., III., 1716, II., III.; Champaign, Oct. 19, 6329, II., III., Oct. 24, 6334, II., III.

A most peculiar species. From two thirds to three fourths or more of the teleutospores are septate, presenting the most varying and aberrant forms. So far as we are informed this has not been previously found in America, but a comparison with specimens kindly furnished by Dr. M. C. Cooke, of *Puccinia flaccida*, B. & Br., from Ceylon, leaves no doubt of the specific identity. The American specimens only differ in possessing more undivided, and upon the average, narrower teleutospores, with somewhat thicker pedicels.

P. andropogi, Schw.

II., III. Hypophyllous. Sori rather small, usually very numerous, elliptical, sometimes confluent in small, elongated groups, soon naked, surrounded by the lacerated remains of the epidermis; uredospores subglobose, epispore rather thick, tuberculate, 21–30μ; teleutospores mostly obovate, but varying to elliptical and clavate, slightly constricted at the septum, usually thickened at the vertex, obtusely rounded or sometimes short-

pointed, smooth, dark-brown, 15–22 by 30–45 μ; pedicel usually about the length of the spore, sometimes longer, more or less tinted.

Spots obliterated, sori densely aggregated, elevated, fuscous, obtuse, linear, abbreviated. Spores fuscous. Although not confluent, yet occupying almost the entire leaf. Very frequent in autumn in leaves, culms and sheaths of various species of *Andropogon.*—Schweinitz, N. Am. Fung., No. 2911, p. 295.

On *Andropogon furcatus:* Boone, Sept. 2, 1423; Ogle, Sept. 26, 6184, II., III.; Rock Island, Sept. 27, 1678. *A. scoparius:* Ogle, Sept. 25, 6172, II., III., Sept. 26, 6200, II., III.; Union, Oct. 22, 1960.

In Thümen's Mycotheca Universalis, No. 1336, the specimens named *Puccinia Ellisiana*, Thüm., which Farlow identifies (Proceed. Am. Acad. Arts & Sc., July, 1883, p. 81) as *P. andropogi*, Schw., the teleutospores are often more narrow and pointed, are lighter in color, and the pedicels are longer than in the Illinois specimens.

In the specimens examined the uredospores vary considerably, even on the same leaf, as well as upon different hosts.

P. maydis, Carradori.

II., III. Amphigenous. Sori subcircular to oblong, irregularly scattered, often confluent, rather tardily rupturing the epidermis, whose upturned edges persistently remain; uredospores subglobose, epispore rather thick, echinulate, 25–30 μ. Teleutospores broadly elliptical, considerably constricted at the septum, ends mostly obtusely rounded, but sometimes thickened at the apex and variously pointed, smooth, 15–22 by 30–45 μ; pedicel slightly colored, once to twice the length of the spore.

P. sorghi, Schw. Spots none; sori broad, of different forms, variously lobed, at first covered by the epidermis, then denudated but surrounded by the lacerated epidermis, often also internally fissured, 2–4 lines long and broad. Many of the sori occur on the nerves of the leaves. Spores black, large; pedicels short.—Schweinitz, N. Am. Fung., No. 2910, p. 295.

On leaves of *Zea Mays:* McLean, July 20, 2345, II., III., Aug. 4, 2344, II., III., Aug. 19, 5636, II., III., Sept. 6, 5664, Oct. 11, 1830; Champaign, Aug. 13, 1032, II.; McHenry, Aug.

20, 1165, II., III., Aug. 23, 1239, II., III.; Lake, Aug. 27, 1349; Lee, Sept. 8, 5720, II., III.; JoDaviess, Sept. 16, 5958, II., III.; LaSalle, Sept. 28, 6216, II., III.; Fulton, Oct. 1, 1765.

This is *Puccinia Sorghi*, Schw. (N. A. Fungi [1834], p. 295). The above name was published in 1815 (see Rabh. Krypt. Fl. I. p. 181).

PHRAGMIDIUM, LINK.

Teleutospores divided by two or more horizontal septa, producing three or more cells in a single vertical row; teleutosori prominent, usually small, tufted, sometimes confluent in patches; uredospores one-celled, borne on deciduous pedicels; æcidiospores produced in vertical chains as in the true Æcidia, but without pseudoperidium; uredosori and æcidiosori surrounded by a thick row of club shaped, or more or less capitate, incurved paraphyses.

All the sporeforms of the *Phragmidia* are ordinarily hypophyllous, the æcidium and uredo appearing rather early in summer, and the teleutoform after the first of July; but the two latter are very commonly found together during the later parts of the season. Sometimes the fungi are seated upon the petioles and stems of the host. All grow upon species of *Rosaceæ*, and so far as discovered, upon plants of the genera *Potentilla*, *Rubus* and *Rosa*.

The æcidium has only recently been distinguished from the uredo, the sori of the two stages being mostly very similar, and determined by the manner of the production of the spores, as just indicated. It is somewhat remarkable that in the æcidium stage there is no peridium, hence, according to the characteristics adopted in this paper, the genus form is *Cæoma*, not *Uredo* or *Æcidium*.

Ph. fragariæ, (DC.) Rossm.

II., III. Hypogenous. Uredosori small, circular, without paraphyses, scattered; uredospore elliptical or obovate, echinulate, each borne upon a pedicel, 14–16 by 16–21 μ; teleutosori scattered, rather large, circular, prominent, powdery, chestnut-

brown, teleutospores usually three, sometimes two, more often four-celled, oblong or broadly clavate, somewhat constricted at the septum, vertex slightly thickened, obtusely rounded, narrowed toward the base, epispore thin, smooth, 21–27 by 36–90 μ; pedicel hyaline, tapering below, from one third to one half the length of the spore.

On leaves of *Potentilla Canadensis*: Union, April 16, 5015, II., April 26, 4311, II., April 29, 4390, II.; Jackson, April 19, 4177, II., April 28, 4366, II.; Pulaski, May 9, 4579, II.; Johnson, May 12, 4651, II.; LaSalle, June 15, 4999, II., Sept. 28, 6223, III., Sept. 29, 6232, III.; Adams, June 27, 5307, II., July 3, 5384, II., July 5, 5407, II., 5417, II., July 6, 5441, II., July 10, 5461, II.; McLean, July 26, 2415, II.; McHenry, Aug. 25, 1321, II., III.; Stephenson, Sept. 13, 5816, II.; JoDaviess, Sept. 15, 5896, III.; Ogle, Sept. 26, 6188, II., III.; Fulton, Oct. 3, 1731, II., III.; Jersey, Oct. 12, 6274, III.

This is *Ph. triarticulatum*, B. & C.; but there is little reason to consider the American specimens specifically distinct from the European *Ph. fragariæ*, according to Winter's description (Die Pilze, p. 228), and the specimens in Rabh. Herb. Myc., 281. On neither the latter nor the Illinois specimens was there observed any roughness of the epispore.

Ph. mucronatum, (Pers.) Lk.

I., II., III. Æcidia amphigenous, on the leaves more commonly hypophyllous, and of different sizes, but usually small, in little groups on a distinct reddish, yellow-bordered spot, on the larger veins, petioles, and young stems confluent and swollen, conspicuous, causing more or less distortion of the host, surrounded by clavate, incurved, colorless paraphyses, bright orange-colored; æcidiospores subglobose or angular, produced in erect chains, becoming rough-warty towards maturity, 18–24 μ; uredosori hypophyllous, small, scattered, very numerous, sometimes sparingly confluent, surrounded by many incurved, clavate, colorless paraphyses, yellow; uredospores subglobose, rough-warty, each produced on a pedicel, 18 μ; teleutosori hypophyllous, scattered, small, powdery, brownish-black; teleutospores cylindrical or oblong-elliptical, vertex narrowed and mucronate, apiculus hyaline, six- to eleven-septate, rather coarsely

tuberculate, 24 by 65–77 μ; pedicel about one and a half times the length of the spore, mostly hyaline, swollen, and elongate-elliptical from above the middle downward.

Puccinia mucronata. Crowded, black, spores pediceled, cylindrical, mucronate. Var. *Rosæ.* Spores somewhat swollen, obtuse, parasitic on *Uredo Rosæ.*— Persoon, Syn. Fung., p. 230.

On *roses:* Jackson, April 28, 4376, I.; Pulaski, May 4, 4486, I., 4487, I., May 9, 4580, Nov. 4, 2247; Johnson, May 12, 4639, I., 4640, I., 4641, I., May 13, 4671, I., May 16, 4706, I.; McLean, May 20, 4725, I., May 25, 4778, I., May 29, 4813, I.; Champaign, June 8, 4917, I., June 10, 4941, I., 4958, II., July 11, 6494, I., II., III.; LaSalle, June 15, 5000, I., June, 21, 5256, I.; McHenry, Aug. 20, 1159, II., III., Aug. 26, 1317, II., III., Aug. 27, 1342, Aug. 31, 1394, Sept. 1, 1416, II., III.; Lee, Sept. 8, 5713, II., III.; Stephenson, Sept. 13, 5825, II., III.; JoDaviess, Sept. 19, 5997, II., III.; Ogle, Sept. 23, 6131, I.; Rock Island, Sept. 27, 1683; Henry, Sept. 28, 1718; Union, Oct. 21, 1909, Oct. 29, 2121, Oct. 31, 2135, Nov. 3, 2197.

Persoon's name (Disp. Meth. [1797] p. 38) for this plant is *Puccinia mucronata* var. *Rosæ.* As the other variety has been given another name, this should bear the name of the species rather than of the variety. Link introduced (Spec. Plant. II. [1824–25] p. 84) the genus *Phragmidium*, in which this species is included, hence *Ph. mucronatum*, Lk., is often written. The supposed æcidioform described above, referred to under *Ph. speciosum*, sometimes occurs in midsummer at the same time on the leaves with the uredo and teleutospores. The paraphyses are identical in the forms I. and II., and persist with the teleutoform.

Ph. speciosum, Fries.

III. On the stems, and less commonly on the petioles, forming swollen, distorted areas of more or less extent. Sori irregularly confluent, grayish-black, on year-old stems crust-like; spores cylindrical-oblong, about five to seven celled, sometimes less, scarcely or not at all constricted at the septum, ends rounded, apex mucronate, smooth, almost black, 30 by 60–90 μ; pedicel hyaline below, tinted above, tapering downward, very long, attaining seven or more times the length of the spore.

On *Rosa:* Pulaski, May 4, 4487, May 9, 4580: Johnson, May 12, 4640, 4641, May 16, 4706; McLean, May 25, 4778, May 29, 4813: Champaign, June 10, 4941: LaSalle, June 15, 5000, June 21, 5256; JoDaviess, Sept. 16, 5952; Ogle, Sept. 23, 6131; Jersey, Oct. 12, 6273.

What has been called *Uredo miniata*, Pers., *Caeoma miniata*, Schl., or *Coleosporium miniatum*, Lév., has been considered the aecidioform of *Phragmidium mucronatum*, Pers., with which it is certainly often associated. But it is very commonly found on the green leaves, in the early part of the season, with *Ph. speciosum* on the twigs at the same time. Sometimes, however, the teleutospores of *Ph. mucronatum* occur later in the season on the Caeoma-affected leaves or on other leaves of the same plant.

All the numbers except 5952 and 6273 were accompanied by the above mentioned form.

Ph. rubi-idæi, (Pers.) Winter.

II., III. Hypophyllous. Uredosori small, scattered, usually very numerous; uredospores obovate or elliptical, epispore thin, sharply echinulate, 15–18 μ; teleutosori small, scattered, powdery, black; teleutospores cylindrical, ends obtusely rounded, vertex furnished with a more or less elongated, conical, or often somewhat cylindrical hyaline apiculus, whole surface very rough-warty, almost black, about six- to eight-septate, 27–33 by 67–120 μ; pedicel tinted near the spore, otherwise hyaline, about one and a half times the length of the spore, from above the middle downward elongate-elliptical, roughened.

On leaves of *Rubus strigosus:* McHenry, Aug. 20, 1177, Aug. 23, 1232; Boone, Sept. 2, 1422, II.; Cook, Sept. 5, 1446, II.; Stephenson, Sept. 14, 5882, II., III.; JoDaviess, Sept. 20, 6012, II.

The teleutosori are surrounded by many incurved colorless (dry specimens) clavate paraphyses, but a careful examination of the specimens failed to reveal them with the uredosori, though these were over-mature, and the spores everywhere scattered among the matted hairs of the leaf.

Ph. rubi, (Pers.) Winter.

II., III. Hypophyllous. Sori, very small, scattered; uredosori often very numerous, circular, orange-yellow, without paraphyses; uredospores ovate or elliptical, each borne upon a pedicel, epispore thin, finely echinulate, 12–15 by 15–20 μ; teleutosori rounded, sometimes confluent, black; teleutospores about four to five septate, cylindrical, somewhat constricted at the septum, ends obtusely rounded, the vertex furnished with a conical, more or less deeply tinted apiculus, surface finely tuberculate, sometimes appearing smooth, dark-brown, 36 by 100 μ; pedicel as long as the spore or somewhat longer, very much swollen in the lower half.

On *Rubus villosus:* Lee, Sept. 8, 5711, II., III.; JoDaviess, Sept. 15, 5908, II.; Sept. 18, 5979, II., Sept. 19, 5999, II.; Ogle, Sept. 23, 6147, II.; Jersey, Oct. 14, 6313, II.; McLean, Oct. 18, 1874, II.

TRIPHRAGMIUM, LINK.

Teleutospores dark brown, three-celled, triangular, the dividing septa vertical and horizontal or oblique; uredospores similar to those of *Puccinia.*

In this genus æcidioforms have not been certainly recognized, though there are in some cases what have been called two forms of the uredo, the one occurring in the spring on the petioles and veins, the other late in the summer on the leaf surfaces, and spermogonia are developed upon the upper leaf-surface.

The species are comparatively few; none have so far been found in Illinois.

RAVENELIA, BERKELEY.

Teleutospores many-celled, berry-like, with vertical and horizontal septa, usually with a series of hyaline cells at the base, pedicellate or sessile.

This curious genus is comparatively little known, and its standing among the *Uredineæ* has not been firmly established.

It seems the germination of the spores has not been observed neither have other spore forms been certainly found as genetic productions. In *R. stictica*, B. & Br., however, Berkeley says: "The larger pseudospores are accompanied by uredinoid bodies which are minutely papillate." (Linn. Soc. Jour. Bot., Vol. XIV, p. 93.)

The spores attain the largest size among the *Uredineæ*, and are otherwise very readily generically recognized.

Speaking of *R. indica*, Berkeley says, "The glandular bodies consist of a large umbrella-shaped, dark cap, often $\frac{1}{250}$th of an inch across, composed of a number of closely packed cells, supported by a long, hyaline, delicate, and apparently compound stem, round the end of which are suspended a circle of elongated hyaline bodies, calling to mind, in point of arrangement, the appendages of some species of Medusæ, or in general appearance the fruit of some Marchantia. In the South Carolina species [*R. glandulosa*, B. & C.] on the contrary, the peduncle is shorter and the appendages are united by their sides into a solid mass."

The species grow on various *Leguminosæ*.

R. glandulæformis, B. & C.

Amphigenous. Sori scattered, rather small, often confluent in areas of variable, sometimes of considerable size, testaceous; spores broadly capitate, the many-celled, dish-like, chestnut-brown upper layer projecting over the hyaline cells beneath, about 75 to 100 μ; pedicel short, hyaline.

Spores urn-shaped, with a short pedicel, hyaline below and lobed or striate; even above, cellular, colored, projecting beyond the lower division. In some specimens the lower division is even, and the cells of the upper part larger, but it is probably a mere form.—Berkeley, Grevillea, III., p. 80.

On *Tephrosia Virginiana*: "Pine Hills," Union County. Collected several times in same locality by F. S. Earle.

GYMNOSPORANGIUM, DC.

Spores with one horizontal septum, less commonly one to six cells in a vertical row, yellow, with epispore thin, on long, slender, hyaline pedicels, imbedded in gelatine, which, when moist, swells into a soft columnar or irregular body. Parasitic on the leaves and branches of various *Cupressineæ*.

The species now assigned to this genus were formerly separated, and a part of them, having the gelatinous material more or less columnar, made to form the genus *Podisoma*. The distinction is not properly generic, and at present most mycologists unite all the species under the generic name of *Gymnosporangium*. The European species agree in the spores having a single septum, and this is usually made a characteristic of the genus, but some of the American species, otherwise similar, have from one to six-celled spores, so that the description of the genus is necessarily extended to include them. The spores are produced in the spring instead of in the autumnal months, as are the teleutospores of most *Uredineæ;* but they germinate in May and June, hence have not a long period of rest. The promycelium is rapidly formed, under the proper conditions, from the mature spores, and sporidia are abundantly produced. These latter are believed to develop only on species of *Pomeæ*, and produce the æcidial growths included under the so-called genus *Ræstelia*. This alternation of growth has been several times experimentally shown, but for the purposes of this paper the æcidial forms are given by themselves. The mycelium of the teleutosporic form is sometimes annual, but more often perennial, and produces remarkable gall-like distortions upon the host.

G. macropus, Lk.

Sporiferous masses aggregated in globose tufts, surrounded at the base by a ring formed by the raised epidermis and subepidermal tissue of the host-plant, orange-yellow, cylindrical, acuminate, half an inch to an inch long, or at times longer; spores ovate-acute, two-celled, generally constricted at the septum, and with a papilla at the apex, 15–20 by 46–60 μ; promycelia generally four from each cell. Mycelium annual, producing globose or reniform knots in the smaller branches. On leaves and smaller branches of *Juniperus Virginiana*. (Farlow, Gymnosporangia of the U. S., p. 13.)

On *Juniperus Virginiana:* Union, May 15, 4705; Champaign, March 16, 2465.

CRONARTIUM, Fries.

Teleutospores one-celled, without pedicels, compacted in an erect (often curved or bent) cylindrical, solid column; uredospores produced on pedicels, the uredosorus covered by a pseudoparenchymatous membrane.

The peculiar column, composed of the elongated teleutospores adhering closely to each other, and rising conspicuously from the substratum, clearly designates this genus. The uredospores and teleutospores, so far as known, are produced on the same host, sometimes in the same sorus.

C. asclepiadeum, Kze.

Var. thesii, Berk.

II., III. Uredosori small, scattered, or collected in irregular groups, furnished with a peridium; uredospores subglobose to elliptical, echinulate, 15 by 18–27 μ; teleutosori scattered, often numerous, column long, cylindrical, usually curved; teleutospores oblong or cylindrical, yellowish-brown, smooth, about 11 μ in diameter.

On *Comandra umbellata:* McHenry, Aug. 20, 1157, Aug. 23, 1245; Boone, Sept. 2, 1428; LaSalle, Sept. 13, 1498, Sept. 16, 1552; Ogle, Sept. 26, 6199.

The determination of the variety was made by comparison with the specimens in Ellis' North American Fungi, No. 1082.

This is *Cronartium comandræ*, Peck (Bot. Gaz. IV, p. 128).

MELAMPSORA, Cast.

Teleutospores one or more celled, when divided the septa mostly vertical (sometimes horizontal or oblique), sessile, densely compacted in a firm, flat or slightly convex layer; uredospores single celled, sessile upon the hymenium, the sori usually covered by a membrane, which is finally irregularly ruptured.

This genus, as here defined, includes not only what has been uniformly assigned to it, but the species which have been

by different authors assigned to *Calyptospora*, *Melampsorella*, *Phragmospora* and *Thekopsora*. Admitting all these as genera of equal rank, the characteristics may be given as follows:

Teleutospores produced beneath the cells of the epidermis:
- Teleutospores one-celled................MELAMPSORA.
- Teleutospores divided.................PHRAGMOSPORA.

Teleutospores produced *in* the cells of the epidermis.
- Teleutospores one-celled, colorless.....MELAMPSORELLA.
- Teleutospores divided, colored:
  - Sori small, with uredo ....THEKOPSORA.
  - Sori broadly confluent or effused, without uredo, CALYPTOSPORA.

With the single exception of *Melampsora Gœppertiana* (*Calyptospora Gœppertiana*, Kühn) on various species of *Vaccinium*, no supposed æcidium form has been found; in this case the almost universal association of the teleutoform on *Vaccinium*, and one or more species of *Peridermium* on *Pinus* and *Abies*, seems to strongly indicate their genetic relation. Other observations corroborate the supposed connection, so that, in Europe at least, we may accept the matter as a fact that this species of *Melampsora* and *Æcidium (Peridermium) columnare*, Alb. & Schw., are alternate forms. In America, *Peridermium balsameum*, Peck, seems to be associated with the teleutoform, but whether *P. balsameum* and *P. columnare* are specifically identical has not been determined. See Farlow, Appalachia, Vol. III. (1884) p. 241 *et seq.*

M. epilobii, (Pers.) Fkl.

II., III. Hypogenous. Uredosori scattered, minute, hemispherical, then opening by a circular stoma; uredospores obovate, sometimes varying to subglobose and oblong, epispore thin, sharply echinulate, each produced on a pedicel, orange-yellow, 12–15 by 14–18 μ; teleutosori irregular, scattered, often confluent in irregular crust-like areas, becoming chestnut-brown, or at length darker; teleutospores mostly one-celled, often divided by a septum which is horizontal, oblique, or vertical, cuboidal or elongated, epispore thin, smooth, 21–39 μ long.

Uredo pustulata, var. *Epilobii:* subrotund, flavescent, minute, little prominent, closed, collected in little clusters.—Pers. Syn. Fung. p. 219.

Melampsora epilobii, Fckl. F. rh. 300. I., II.—I. Fungus stylosporiferus. Uredo Epilobii DC. Fl. Fr. II. p. 226. On leaves of Epilobium montanum, roseum and angustifolium, plentiful in summer. II. Fungus teleutosporiferus. Sori plane, confluent, black-fuscous; teleutospores obovate-clavate, fuscous. On the under surface of withered leaves of *Epilobium angustifolium*; rare in autumn —Fuckel, Symb. Myc. p. 44.

On *Epilobium coloratum:* JoDaviess, Sept. 20, 6019, II.

Persoon described (Syn. Fung. p. 219) *Uredo pustulata* var. *epilobii*, and DeCandolle wrote *Uredo epilobii* (Flora Franc. II. p. 226), and Fuckel described the teleutoform and referred the uredo to same species. The name *Uredo pustulata*, Pers., has been used for various species.

M. crotonis, Burrill.

II., III. Amphigenous. Uredosori scattered, rather prominent, circular, cinnamon-colored; uredospores obovate, sharply echinulate, produced on pedicels, 15–21 by 18–27 μ; teleutosori irregular, scattered or somewhat confluent, slightly elevated, reddish brown; teleutospores irregular, mostly elliptical or oblong, one, two, or more celled, arranged in an irregular layer composed of variously imbricated spores, smooth, cell-contents granular, pale to dark brown, 11–15 by 30–42 μ.

Trichobasis crotonis, Cooke. Amphigenous; sori minute, subrotund, surrounded by the ruptured epidermis, fuscous: pseudospores globose or ovate, finely warty (28–30 μ diam.). On leaves of Croton procumbens, California.—Cooke, Grevillea, VI., p. 137.

On leaves of *Croton capitatum:* Marion, Oct. 20, 1900, II., III. *C. monanthogynus:* Johnson, May 12, 4649, II.; Jersey, Oct. 12, 6282, Oct. 14, 6322; Jackson, Oct. 22, 1945, II., III.; Nov. 5, 2266; Union, Oct. 25, 2010, II., III., Oct. 31, 2157, II., III., Nov. 1, 2211. *Crotonopsis linearis:* LaSalle, Sept. 28, 6226.

The uredo is *Trichobasis crotonis*, Cke. The teleutoform seems to belong to the group separated by Magnus under the generic name of *Phragmospora*, but it is not easy to make out the relation of the spores to the cells of the host in dried specimens.

M. salicina, Lév.

II., III. Amphigenous, the uredo mostly hypophyllous, and the teleutoform more often epiphyllous. Uredosori small, circular, often thickly spread over the leaf surface, surrounded by a thick row of paraphyses, which are strongly enlarged and rounded above: uredospores subglobose or elliptical, finely echinulate, 12–15 by 14–18 μ; teleutosori various in size, usually flat, irregular, often thickly associated or confluent, crust-like, becoming reddish brown or dark brown; teleutospores oblong, in transverse section polygonal, about 10 by 30–37 μ.

On leaves of *Salix cordata:* McHenry, Aug. 23, 1242, II., Aug. 24, 1276 and 1271. *S. longifolia:* McHenry, Aug. 24, 1254, II., Aug. 31, 1396, II., III.: Lake, Aug. 27, 1350, II., III.: Lee, Sept. 11, 5780, II.; LaSalle, Sept. 14, 2500, II., III.: Henry, Sept. 28, 1707, II. *Salix sps.:* McLean, July 18, 2498, II., July 20, 2497, II., Aug. 4, 2499, II.; Piatt, Aug. 17, 1096, II.; McHenry, Aug. 24, 1278, II., 1288, II.: Lake, Aug. 27, 1351, II., III.: Kane, Aug. 30, 1375, II., III.; LaSalle, Sept. 20, 1599, II., III.: Rock Island, Sept. 21, 1618, II.: Jersey, Oct. 14, 6315, II., III.: Union, Oct. 24, 1977, II.: Pulaski, Nov. 4, 2228, II., III.

Thümen thinks what is included in the above should be separated into the following species, for which he has given descriptions: *M. Biglowii*, *M. capreanum*, *M. Hartigii*, *M. medusæ*, *M. vitellinæ*, (Hedwigia XVIII. [1879] p. 77, and Bulletin Torrey Botanical Club, VI. p. 216).

M. populina, Lév.

II., III. Amphigenous. Uredosori small, scattered over the surfaces of the leaves, usually more numerous below, circular, surrounded by a dense row of paraphyses, which are clavate or strongly enlarged and rounded above, powdery, orange-yellow: uredospores varying from subglobose to oblong or clavate, echinulate, 13–20 by 21–30 μ; teleutosori scattered, mostly thickly studding both surfaces of the leaf, flat, compact, crust-like, often confluent, reddish brown; teleutospores oblong, prismatic, epispore thin, smooth, one-celled, 15 by 36–45 μ.

On leaves of *Populus tremuloides:* McHenry, Aug. 20, 1196. *P. monilifera:* Tazewell, July 22, 2509, II.; McLean,

July 25, 2508, II., Aug. 28, 5612, Oct. 6, 1809, III., Oct. 18, 1884, III.; Piatt, Aug. 10, 1003, II.; Champaign, Aug. 11, 1019, II., Oct. 31, 6376; Lee, Sept. 9, 5751, II.; LaSalle, Sept. 13, 1508, III., Sept. 17, 1586, II.; JoDaviess, Sept. 15, 5909, II., III.; Henry, Sept. 28, 1722, II., III.; Fulton, Oct. 1, 1781, III.; Jackson, Nov. 5, 2261, III.

COLEOSPORIUM, Lév.

Teleutosori divided by horizontal septa (about three) so as to form unbranched vertical rows of closely connected cells, each of which emits, on germination, a promycelium bearing a single sporidium, compacted in a dense flat or convex somewhat waxy stratum; uredospores produced in chains, which soon break up into a powdery mass; sorus naked.

The species of this genus are difficult to determine morphologically one from another, and comparatively little has been done towards elucidating life histories through cultures. It is supposed that *Coleosporium senecionis* and *Peridermium pini* are alternate forms of one species, but other æcidial states are unknown. The so-called uredospores are produced in chains, and according to the classification adopted here would, by themselves, fall in the genus *Cæoma*. The query arises as to whether this should be looked upon as the æcidium or uredo stage. So far as observed this form grows on the same leaf, and usually just before the teleutoform, characteristics of the latter rather than the former. If, indeed, *Peridermium pini* is the æcidium form of *Coleosporium senecionis*, then the pulverulent spores on *Senecio*, one would say, must be the uredo form, and these are very similar to the first-formed spores of the other species.

C. sonchi-arvensis, (Pers.) Lév.

II., III. Hypogenous, rarely epiphyllous. Uredosori scattered or united in groups, often very numerous and sometimes crowded or confluent, elliptical or irregular, powdery; uredospores elliptical, often irregular, thickly studded with little obtuse tubercles, orange-yellow, but soon fading, 15–21 by

19–24 μ; teleutosori scattered or united in groups, often very numerous and sometimes confluent. low. at first orange-yellow, changing to pale reddish brown; teleutospores about four-celled. cylindrical or enlarged above, epispore thin, smooth.

Uredo sonchi-arvensis. Crowded, subconfluent, fulvous, sori nearly plane, irregular. Hab.: frequent in autumn on leaves of *Sonchus arvensis* in fields after harvest.—Persoon, Syn. Fung., p. 217.

On leaves of *Vernonia fasciculata:* Tazewell, July 22, 2491, II.; Champaign, Aug. 11, 1023, II., III.; Piatt. Aug. 15, 1070, II., III., Aug. 17, 1111, II., III.; McLean, Sept. 6, 5671, II., III., Oct. 6, 1810, II., III., Oct. 13, 1862, II., III.; LaSalle, Sept. 14, 1545, II., III., Sept. 29, 6240, III.; JoDaviess, Sept. 15, 5911, II.; Jersey, Oct. 13, 6296, II., III.; Jackson, Oct. 22, 1955, II., III.; Union, Oct. 24, 1970, 1984, II., III., 1985, II., III., 1986, II., III., Oct. 26, 2034, Oct. 27, 2067, II. III.; Pulaski, Nov. 4, 2233. *Elephantopus Carolinianus:* Union, Oct. 26, 2033, II., III. *Aster sagittifolius:* Jackson, April 21, 4213, II.; Pulaski, May 5, 4508, II., 4509, II., May 6, 4532, II., May 10, 4592, II.; McLean, July 12, 2488, II., July 15, 2486, II., July 29, 2487, II., Aug. 1, 2463, II., III., Aug. 6, 2485, II., 2489, II., Oct. 18, 1885, II., III.; McHenry, Aug. 20, 1162, II.; LaSalle, Sept. 13, 1507, II.; Stephenson, Sept. 13, 5823, II., Sept. 14, 5881, II., III., JoDaviess, Sept. 16, 5950, II.; Rock Island, Sept. 27, 1685, II.; Fulton, Oct. 3, 1741, II. *Aster sps.:* Jackson, April 25, 4292, II.; Johnson, May 12, 4650, II.; Adams, July 11, 5499, II., 5500, II.; McLean, Aug. 1, 2490, II.: Piatt, Aug. 10, 1008, II.; McHenry, Aug. 24, 1283, II.; Cook, Sept. 6, 1452, II.; JoDaviess, Sept. 19, 5998, II.; Fulton, Oct. 3, 1736, II., III.; Union, Oct. 21, 1906, II., III. *Solidago latifolia:* McLean, Aug. 1, 2481, II., Aug. 6, 2483, II., 2484, II., Oct. 12, 1853, II., III. *S. altissima:* Adams, July 1, 5378, II., July 3, 5386, II., July 7, 5448, II.; Lee, Sept. 9, 5752, II. *S. ulmifolia:* McLean, Aug. 6, 2482, II.; LaSalle, Sept. 17, 1570. *S. Canadensis:* Adams, July 11, 5498, II.; McLean, July 12, 2479, II., July 15, 2478, II., 2480, II., III., July 16, 2477, II., Aug. 6, 2476, II., Oct. 18, 1879, II.; McHenry, Aug. 20, 1178, II., Aug. 24, 1279, II.; Stephenson, Sept. 13, 5817, II.; Rock Island, Sept. 24, 1619, II., III., Sept. 27, 1684, II., III.; Fulton, Oct. 3, 1743, II.; Union, Oct. 25, 2006, II., III., Oct. 27, 2060, II.,

2066, II., Nov. 1, 2205, II., Nov. 4, 2273, II. *S. gigantea:* McLean, Sept. 6, 5672, II. *Solidago sps.:* Union, April 26, 4312, II., April 29, 4393, II.; Pulaski, May 3, 4466, II.; Adams, June 26, 5289, II., July 5, 5418, II.; Piatt, Aug. 15, 1077, II., Aug. 17, 1112, II.; Ogle, Sept. 26, 6187, II.; Union, Oct. 21, 1912, II. *Silphium integrifolium:* Union, Sept. 22, II., III., (Earle.) *S. terebinthinaceum:* Jersey, Oct. 13, 6298. *Helianthus:* Piatt, Aug. 17, 1130; Jersey, Oct. 13, 6297, II., III., Oct. 14, 6311; McLean, Oct. 12, 1847, II., III., Oct. 18, 1878.

Nos. 1912, 2006, 2060, 2205, 2481, 5817, 5881, 5950 and 6187 are accompanied by pycnidia of *Dothidea solidaginis.*

The name adopted is from *Uredo sonchi-arvensis*, Persoon. For the fungi here included many names have been proposed under the idea of specific distinctness. But whatever differences exist seem to be so connected by intermediate forms that those upon the host-plants named are considered specifically identical. There are, therefore, included such as have been named *Uredo Solidaginis*, Schw., *U. terebinthini*, Schw., *Coleosporium compositarum*, Lév., *Uredo* or *Caoma elephantopodis*, Schw., *Coleosporium Vernoniæ*, B.& C., and *C. Solidaginis*, Thüm. Perhaps the form on *Vernonia* differs more than others from the type on account of the uredospores being smaller, and the teleutospores being more enlarged above. On *Elephantopus* the teleutosori are grouped in circles.

C. ipomœæ, (Schw.)

II., III. Hypophyllous. Spots yellowish or none; sori minute, scattered or irregularly clustered, circular. II. Spores irregularly oval, strongly echinulate, 18 by 26 μ. III. Sori convex, deep reddish orange; spores (chains) oblong or slightly clavate, conspicuously 4–6-septate, about 10 by 26 μ, segments widest transversely.

On leaves of *Ipomœa Nil:* Union, Oct. 31, 2133, II., III.; Jackson, Nov. 5, 2265, II., III. *I. lacunosa:* Union, Oct. 31, 2134, II., III. *I. pandurata:* Tazewell, July 22, 2462, II., III.; McLean, July 29, 2292, II., III., Oct. 13, 1861, II., III.; Piatt, Aug. 15, 1068, II., III., Aug. 17, 1108, II., III., 1136, II., III.; Jersey, Oct. 12, 6271, II., III.

This is evidently the plant named *Uredo ipomœæ* by

Schweinitz, and as such distributed by Ravenel in his Fungi Caroliniani IV. No. 99, and Fungi Americani, No. 488. In both of those specimens the Coleosporium form is found. Our specimens on *Ipomœa Nil* have the spore-chains somewhat more slender, and the color of those examined is not quite so deep as that of those on *I. pandurata.*

CHRYSOMYXA, Unger.

Teleutospores composed of several cylindrical cells in simple or branched vertical rows, the lower cells sterile, each of the upper producing a several-celled promycelium bearing about four sporidia, sorus naked, compact, flat or convex, red or orange-yellow: uredospores in vertical rows, soon pulverulent, sorus naked.

It is understood that *Peridermium abietinum*, (Alb.& Schw.) is genetically related to one or more species of this genus as the æcidium-stage.

Not so far observed in Illinois.

UREDO, Lév.

Spores one-celled, produced singly on pedicels from which they readily separate at maturity, forming a powdery mass; sorus without pseudoperidium, without spermagonia.

Many, perhaps all, are forms of plants belonging to other genera classified by the teleutospores, as *Uromyces*, *Puccinia*, etc., and constitute what is known as the second stage of the *Uredineæ;* but some of the so-called species have not yet been connected even in supposition with any teleutosporic forms. The spores germinate at maturity, and soon lose their vitality; the germ tube produces the mycelium directly, without the intervention of sporidia. The sorus is in some cases surrounded by paraphyses, usually club-shaped and incurved, a charactertic of the so-called genus *Lecythea.*

For the comparison between *Uredo* and *Cæoma*, see the latter.

U. hydrangeæ, B. & C.

Hypogenous. Spots small, yellowish, more or less confluent. Sori minute, scattered, few; spores obovate, produced on pedicels, minutely tuberculate, 12–18 by 16–24 μ.

On *Hydrangea arborescens.*

This name is attached to specimens in the Curtis herbarium, and published in Curtis' Cat. Plts. N. C., p. 122, without description. The specimens from which the description is taken were collected by Mr. F. S. Earle, Cobden, Oct. 13, 1879. There is no evidence of the occurrence of the fungus elsewhere in the State.

CÆOMA, Tul.

Spores one-celled, produced in vertical chains, soon separating in a powdery mass, sorus without pseudoperidium, but sometimes covered by a thin adherent membrane, often with spermagonia, and with or without paraphyses.

The term Cæoma has been used with several and very different significations. As here limited it does duty, probably temporary, as a genus of so-called species of which teleutosporic forms are still unknown. As defined the genus differs from *Uredo* in the manner of the production of the spores, and from *Æcidium* in the absence of a peridium. According to some authors the presence of spermagonia is taken as the special characteristic of *Cæoma* as against *Uredo*, so that with these writers the forms having spores in chains, but without spermagonia, are arranged under the latter, as, for example, the so-called *Uredo agrimoniæ*,—herein found as *Cæoma agrimoniæ*, Schw. It, however, seems pretty evident that, with or without spermagonia, those forms having spores in chains represent rather the æcidial than the uredo stage, and as some species of *Æcidium* have no spermagonia, the absence of the latter in *Cæoma* ought not to be unlooked for.

Some of the so-called *Cæomæ* have been identified as the æcidial forms of *Phragmidium*, which see. Compare also *Coleosporium*.

C. agrimoniæ, Schw.

Hypogenous. Spots yellowish, often confluent and more or less spreading over the surface. Sori small, irregularly, mostly thickly, associated in patches, or over the whole surface, orange; spores subglobose or elliptical, epispore rather thin, finely echinulate, 14–16 by 15–20 μ.

Cæoma (Uredo) agrimoniæ, Schw. Spots lutescent; sori minute, confluent; spores delicate red-orange, at length faded. Often covering the whole under surface of the leaves.—Schweinitz, N. Am. Fungi, No. 2835, p. 291.

On leaves of *Agrimonia Eupatoria:* Johnson, May 11, 4617; McLean, July 7, 2511, July 15, 2513, 5560, July 27, 2514, Aug. 6, 2510, Oct. 6, 1812, Oct. 18, 1877; Tazewell, July 22, 2512; Piatt, Aug. 17, 1118; Lee, Sept. 8, 5710; LaSalle, Sept. 13, 1505, Sept. 17, 1569; Stephenson, Sept. 14, 5880; Ogle, Sept. 22, 6106; Henry, Sept. 28, 1728; Jersey, Oct. 12, 6272. *A. parviflora:* McLean, Sept. 6, 5673.

This has been named *Uredo agrimoniæ;* it was placed by Schweinitz in the *Uredo* section of *Cæoma*, the latter including, according to him, all allied species. But the spores are produced in chains, not borne singly upon a stalk. On this account probably, Bonorden (Beitr. z. Kent. d. Coniomyc. p. 20) assigned it to the genus *Coleosporium*, hence it is known as *Coleosporium ochraceum*. Without question, however, the form is not the teleuto stage. Until the latter is known it must therefore be *Cæoma*, and the specific name should, at all events, stand as above.

C. nitens, Schw.

Hypophyllous. Sori irregular, flat, usually thickly associated and confluent, more or less covering the surface, bright orange-yellow; spores subglobose, elliptical or oblong, epispore thin, finely tuberculate, 12–24 by 18–32 μ; spermagonia scattered, numerous, yellow, mostly on upper side of leaf.

On *Rubus occidentalis:* McLean, May 20, 4722, May 25, 4777, May 26, 4792; LaSalle, June 15, 4993. *R. villosus:* Union, April 16, 5016, April 17, 4140, April 24, 4258, April 26, 4310, April 27, 4332, April 28, 4375, April 29, 4391; Jackson,

April 19, 4176, April 28, 4367; Pulaski, May 1, 4403, May 6, 4531, May 9, 4578; Johnson, May 13, 4670; McLean, May 23, 4749, May 26, 4791; Champaign, June 8, 4903; LaSalle, June 16, 5208; Adams, July 3, 5387.

Schweinitz (Syn. Car. 458) calls this *Æcidium nitens*, and afterwards (Syn. N. A. Fungi) *Caeoma* (sub-genus *Æcidium*) *luminatum*. The last name has been most often used, but without proper authority.

This is the well known orange rust of the blackberry, and more rarely of the black-cap raspberry, occurring for the most part in May and June. It is unquestionably a first form or undeveloped state of some teleutosporic species, and this has been thought to be a *Phragmidium*. Some recent observation, however, tends to show that it belongs to *Puccinia Peckiana*, Howe, which is found on the same host-plants, and matures in September.

ÆCIDIUM, Persoon.

Spores one-celled, in chains or vertical rows, without pedicels; sorus inclosed in a short, beaker-like pseudoperidium, which protrudes through the ruptured epidermis of the host, and opens regularly at the vertex, the border soon becoming more or less toothed or lobed, and usually recurved; with spermagonia.

This was supposed to be a true genus of autonomous species, but it is now believed that all the supposed species belong to *Uromyces* and *Puccinia*, and constitute what is known as their first or æcidial stage in the alternations of development. Before, however, anything like exact knowledge as to genetic relations can be ascertained, carefully made artificial cultures must be made by competent investigators. Where there is now good reason for accepting the demonstrations as satisfactorily made, the forms have been included in their proper places with the teleutospores; otherwise they follow here under the designation of species.

Æ. ranunculacearum, DC.

Hypophyllous. Spots distinct, yellowish, mostly small; æcidia irregularly and densely clustered, short, erect, or at

length more or less recurved and many times divided, becoming pulverulent, pale yellowish; spores subglobose or elliptical, epispore rather thick, finely but conspicuously tuberculate, 18 by 21–24 μ; spermagonia minute, honey-yellow, mostly scattered on the upper surface of the affected area.

On *Anemone Pennsylvanica:* Champaign, June 9, 4934, June 10, 4956.

Æ. ranunculi, Schw.

Mostly hypogenous. Equally usually densely associated over the whole surface of the leaf, or over definite patches; æcidia recurved, border narrow and many times split; spores subglobose or elliptical, finely echinulate, 15–21 by 18–24 μ; spermagonia numerous, scattered among the æcidia on same side of leaf, minute.

On *Ranunculus abortivus:* Union, April 12, 4030, April 13, 4066, April 14, 4097, April 15, 4106½, April 17, 4131; Jackson, April 18, 4165, April 28, 4363; Pulaski, May 5, 4507; McLean, May 23, 4751, May 29, 4805, May 30, 4840.

Æ. punctatum, Pers.

Hypophyllous. Spots effused, yellowish; æcidia uniformly scattered over large portions or the whole of the leaf-surface, not usually crowded, rather large, deeply divided into few (about four) widely spreading recurved lobes, thin but firm; spores subglobose to oblong, almost smooth, brown, about 18–21 μ, or 15–18 by 21–27 μ; spermagonia uniformly and remotely scattered on both surfaces, conspicuous, reddish brown.

Simple, scattered, peridia subimmersed, mouth subcontinuous, powder compact, fuscescent.—Persoon, Syn. Fung., p. 212.

On *Hepatica triloba:* Champaign, May 1. *Anemone nemorosa:* Riverside, near Chicago, June 2. J. C. Arthur.

This is *Æcidium quadrifidum*, DC. There is on *Anemone nemorosa* a species supposed to be different (not so far found in Illinois) known as *Æ. anemones*, Pers., or *Æ. leucospermum*, DC. In this last the pseudoperidium is more often, but less deeply, divided, and the border more distinctly rolled, and the spermagonia are very much less conspicuous, produced, how-

ever, in the same way. The spores have thinner walls, are lighter colored, and are said to be more elongated. In the latter respect, however, the specimens collected by Arthur have spores commonly quadrangular, and considerably longer than wide. A Massachusetts specimen agrees with the typical *Æ. punctatum* except that the spermagonia are confined to the lower side of the leaf. That on *Hepatica triloba* is distinctively *Æ. punctatum*.

Æ. actææ, (Opiz.) Wallr.

Æcidia orderless or in circular groups, on pale spots which later are blackish in the centre; pseudoperidia short-cylindrical, with a white tube and many times split and recurved border; spores polygonal, pale yellow, fine-warty, 16–26 μ in diameter by 30 μ.—Winter, Die Pilze, p. 268.

On *Actæa:* Jackson, April 25, 4288.

The description is taken from European specimens; those from Illinois are not fully developed, but seem to be the same.

Æ. dicentræ, Trelease.

Hypophyllous. Æcidia uniformly and remotely scattered over the entire surface, rather large, prominent, border regularly segmented and quite uniformly and abruptly rolled, firm; spores subglobose or elliptical, epispore thin, minutely tuberculate, 10–13 by 11–16 μ; spermagonia large, disk-like, rather distant in a single row on the margin of the leaf, reddish brown.

On *Dicentra cucullaria:* Jackson, April 20, 4195, April 21, 4211, April 25, 4289, April 27, 4345, April 28, 4360; Union, April 24, 4252; McLean, May 22, 4731, May 23, 4753.

Æ. Mariæ-Wilsoni, Peck.

Hypogenous. Spots small, definite, not thickened, yellowish; æcidia small, short-cylindrical, border narrow, many times split and recurved, subcircinating; spores subglobose or somewhat angular, epispore thin, minutely tuberculate, 11–15 μ; spermagonia preceding and, with the æcidia, mostly on the upper side of the leaf.

Spots orbicular, yellow; subiculum not thickened nor excavated; peridia small, slightly elevated, subcircinating, numerous, the margin distinctly scalloped and reflexed; spores subglobose, orange, becoming pale, .00056–.00062 in. in diameter.—Peck, Rep. N. Y. State Mus., XXIV., p. 92.

On leaves of *Viola cucullata:* Union, April 24, 4246.

This seems to differ from *Æ. violæ* in the leaf-spots not being thickened, in the aecidia and spores, and in the presence of spermagonia. Specimens from Professor Trelease, labelled *Æ. Petersii*, B. & C., on *Viola delphinifolium*, cannot be distinguished from the species described above and earlier named by Peck.

Æ. hibisciatum, Schw.

Hypophyllous. Spots usually few, large, thickened, definite, brown with a yellow border; peridia mostly densely crowded, sometimes irregularly circinate, subimmersed; spores broadly oval, about 18 by 37 μ.

Spots orbicular, yellowish, confluent; peridia irregularly but densely scattered, slender, yellow; spores not compact but loose, yellowish. —Schweinitz, N. Am. Fungi, No. 2877.

On leaves of *Hibiscus militaris:* McLean, July 7, 2429, July 15, 5559.

Æ. geranii, DC.

Hypophyllous. Spots definite, not large, purplish or yellow, scarcely thickened; aecidia circinating, small, short, deeply and rather finely split and much recurved; spores subglobose, epispore thin, thickly tuberculate, 18–21 μ; spermagonia clustered in the center of the spots, on both sides of leaf.

On *Geranium maculatum:* McLean, May 23, 4752, May 29, 4806, May 30, 4833, May 31, 4866, June 1, 4881; Piatt, May 28; LaSalle, June 16, 5205.

Æ. impatientis, Schw.

Hypogenous. Spots sometimes definite, purple, yellow-bordered, more often effused, on the leaves scarcely thickened, on the petioles and stems swollen; aecidia subcircinate or irreg-

ularly scattered, short, deeply and rather coarsely split and much recurved; spores subglobose or elliptical (vertical diameter shorter), epispore thin, apparently smooth, contents finely granular, 15–18 by 18–20 μ; spermagonia clustered above in the centre of the definite spots, otherwise sparsely scattered on both sides of leaf.

On *Impatiens:* Union, April 29, 4396; Pulaski, May 4, 4483, May 8, 4559; McLean, May 31, 4864, June 24, 5280, July 2, 2425, July 5, 2434, July 7, 2436, July 15, 5557; LaSalle, June 16, 5206; Adams, July 3, 5388, 5389, July 7, 5451.

Æ. pteleæ, B. & C.

Mostly hypophyllous. Spots distinct, yellow, thickened; æcidia irregularly clustered, cylindrical, rather long, becoming numerously and deeply split and much recurved; spores subglobose or elliptical, large, conspicuously tuberculate, 21–25 by 24–30 μ; spermagonia not found.

Spots pallid, in a hollow on the under side of the leaves; pseudopodia crowded, short, radiated.—Berkeley, Grev., Vol. III, p. 61.

On leaves of *Ptelea trifoliata:* Adams, June 22, coll. C. A. Hart; Peoria, July 10, 6516.

There is scarcely any doubt but that the plant described above is the *Æcidium pteleæ* of Berkeley and Curtis, though the description in Grevillea is insufficient, and the original specimen in the Curtis collection is so poor that its characters cannot be made out.

Æ. onobrychidis, Burrill.

Hypophyllous. Spots distinct or confluent, somewhat effused, yellowish brown; æcidia subcircinate, crowded, short, border abruptly recurved, rather coarsely dissected; spores subglobose or elliptical, epispore rather thin, studded with low, obtuse tubercles, sometimes united in ridges, 19–24 μ; spermagonia clustered in the center of spots mostly on the upper surface, minute, reddish brown.

On *Psoralea Onobrychis:* LaSalle, June 20, 5249.

Æ. psoraleæ, Peck.

Hypophyllous. Æcidia uniformly distributed over the

leaf, short, soon deeply split and recurved: spores elliptical, epispore rather thick, densely tuberculate, 15–18 by 18–24 μ: spermagonia numerous, uniformly scattered among the æcidia, honey-yellow.

Spots none; peridia abundant, generally occupying all the lower surface of the leaf, rarely a few on the upper surface, short, margin crenulate; spores subglobose and subelliptical, brownish yellow when fresh, yellowish when dry, .0007–.0008 in. long.—Peck, Am. Nat., Vol. VIII., p. 215.

On *Psoralea floribunda:* LaSalle, June 20, 5248.

Æ. leucostictum, B. & C.

Hypophyllous. Spots very small, scarcely evident, not discolored; æcidia very small, irregularly clustered in little groups, short, border narrow, recurved and many times split; spores subglobose, minutely tuberculate, 11–12 by 12–16 μ.

Minute, scattered or collected into small patches.—Berkeley, Grev., Vol. III., p. 61.

On *Lespedeza procumbens:* Johnson, May 11, 4616.

This is named as above in Curtis' Catalogue of the Plants of North Carolina, and described in Grevillea (III. p. 61) as a variety of *Æ. orobi*, Pers. The specific distinction is preferred on account of the difference in size of æcidia and spores as well as the appearance of the former.

Æ. orobi, Pers.

Hypophyllous. Spots usually conspicuous, yellow, not thickened: æcidia scattered or collected in orderless groups, small or medium size, short, border many times split and recurved: spores subglobose, usually somewhat angular, epispore rather thick, studded with low obtuse tubercles, often appearing smooth, 18–21 by 21–24 μ; spermagonia few, mostly on the upper side of leaf, in the center of affected spots.

On leaves of *Amphicarpæa monoica:* LaSalle, June 15, 4989.

This is referred to the above named species with some doubt as to the identification. The æcidia are collected in more definite groups than are found in typical specimens of the species.

Æ. grossulariæ, DC.

Hypogenous. Spots distinct, swollen, yellow; æcidia densely clustered, medium size, edge entire and erect or often many times split and recurved; spores subglobose, epispore very thin, obscurely roughened.

On leaves and fruit of *Ribes rotundifolium:* McLean, May 22, 1730, May 23, 4758, May 29, 4814, May 30, 4836. *Cultivated gooseberry:* McLean, May 31, 4847, coll. C. A. Hart; Champaign, coll. T. J. Burrill.

Æ. epilobii, DC.

Amphigenous. Æcidia scattered rather uniformly over the surfaces of the leaves, sometimes more abundant beneath, short, rather coarsely and deeply split and much recurved; spores subglobose, epispore thin, smooth or nearly so, 15–18 μ; spermagonia honey-yellow, appearing before the æcidia, scattered over both surfaces, more numerous above.

On *Œnothera biennis:* Union, April 29, 5019.

There is much reason to suppose that this is *Uromyces œnotheræ*, Burrill. The specimens on *Œnothera linifolia*, from Jackson county, are, if not identical, exceedingly similar, as may be learned by comparing the descriptions. Moreover, Mr. C. A. Hart collected May 27th, 1883, in McLean county, on the radical leaves of what is supposed to be *Œnothera biennis*, a *Uredo*, which is undistinguishable from the uredo form of this *Uromyces*. The sori of Mr. Hart's specimens are developed on both surfaces of the leaves, but the greater number open on the under side — the only point of difference noted.

Æ. œnotheræ, Peck.

Hypophyllous, or very sparingly produced above. Spots conspicuous, usually purple, scarcely thickened; æcidia crowded in a somewhat definite circle, with a small central vacant area, short, deeply and rather coarsely split and much recurved; spores subglobose, epispore thin, very minutely tuberculate, 15–18 μ; spermagonia few, very inconspicuous, on the upper side of the leaf in the center of the spots, honey-yellow.

Spots orbicular, scarcely thickened, reddish purple, sometimes stained with yellow; peridia short, crowded, generally with a small free central space; spores orange, subglobose, small, .0005 in. in diameter. Not unfrequently a reddish purple dash extends from the spot to the margin of the leaf. The cups sometimes occur sparingly on the upper surface of the leaf. The free central space appears umbilicus-like, and, when present, is a noticeable feature.—Peck, Rep. N. Y. State Mus., XXIII, p. 60.

On *Œnothera biennis:* Union, April 27, 4334; Pulaski, May 8, 4566; McLean, May 20, 4721, May 23, 4757, May 25, 4780, May 29, 4802, May 30, 4824, May 31, 4848, June 1, 4883, June 14, 4975, June 19, 5270; Champaign, June 8, 4892; La-Salle, June 15, 4998; Adams, July 3, 5390.

Æ. sambuci, Schw.

Hypogenous. Spots conspicuous, yellow, swollen; æcidia circinate or more often densely and irregularly crowded, short, deeply split and recurved; spores subglobose, epispore thin, minutely tuberculate, 18–21 μ; spermagonia very few, in the center of the spots on both sides of the leaf.

On *Sambucus Canadensis:* Pulaski, May 5, 4493, 4497; May 8, 4560; McLean, May 31, 4859 (undeveloped), June 1, 4890 (undeveloped).

On the young stems the æcidia often occur in large dense clusters with much distortion of the host.

Æ. diodiæ, Burrill.

Hypophyllous, on the cotyledons and rarely lower leaves. Spots distinct, small, greenish brown; æcidia few, in little irregular clusters, small, short, border little or not at all recurved; spores subglobose or elliptical, epispore rather thin, tuberculate, 17–21 by 21–30 μ; spermagonia rather numerous, scattered, above, not found on many of the spots.

On *Diodia teres:* Johnson, May 13, 4661, May 16, 4700.

This may be the æcidium of *Uromyces spermacoces*, which grows on the same host.

Æ. cephalanthi, Seymour.

Hypogenous. Spots distinct, brown, scarcely thickened; æcidia numerous, irregularly crowded, short, the strongly re-

curved narrow border abrupt, finely divided; spores large, subglobose or elliptical, epispore very thick, very conspicuously reticulately roughened, 28–36 by 33–43 μ; spermagonia scattered over the upper side of infected area, minute, reddish brown.

On *Cephalanthus occidentalis:* Ravenswood, near Chicago, June (A.D. 1883), coll. J. C. Arthur; Quincy, July 12 (A.D. 1883), coll. C. A. Hart.

Æ. houstoniatum, Schw.

Hypophyllous. Æcidia scattered over the entire leaf, small, very short, recurved border narrow, many times split; spores globose or elliptical, often angular, minutely tuberculate, 12–15 by 15–18 μ; spermagonia numerous, conspicuous, appearing before the æcidia, scattered over the entire under surface, occasionally above, purple.

Without distinct spots. Pseudoperidia elevated, pallid, subconical, contracted at the apex, and somewhat excavated. Spores orange. The infected plant, though degenerated, yet flowers.—Schweinitz, N. Am. Fung., No. 2891, p. 293.

On *Houstonia cærulea:* Union, April 16, 5010 (Earle), April 17, 4133, April 26, 4307; Jackson, April 27, 4344, April 28, 4362; Johnson, May 13, 4663.

The infected plants are easily recognized, as the fungus causes them to grow more slender and more strictly erect, often taller, and gives them a yellowish appearance.

Æ. erigeronatum, Schw.

Hypophyllous. Spots usually distinct, large, swollen, yellow; æcidia subcircinate or irregularly crowded, short, soon many times divided and much recurved; fragile, soon becoming pulverulent; spores subglobose, epispore thin, tuberculate, 12–15 μ; spermagonia indistinct, few, usually centrally crowded, mostly on upper side of leaf, yellow.

Spots large, yellowish, somewhat swollen, pseudoperidia densely distributed, without order, elevated, spores yellowish.—Schweinitz, N. Am. Fungi, No. 2869, p. 292.

On *Erigeron Canadense:* Adams, June 27, 5306, July 6, 5434. *E. bellidifolium:* Johnson, May 13, 4664, May 16, 4699.

E. Philadelphicum: Union, April 17, 4136; Champaign, June 8, 4916. *E. annuum:* Johnson, May 12, 4634, May 13, 4666; Champaign, June 8, 4893, June 10, 4953; Adams, June 27, 5305, July 6, 5433.

Æ. asterum, Schw.

Hypophyllous. Spots usually distinct, somewhat swollen, yellow or purple; æcidia subcircinate or irregularly crowded, short, deeply divided and recurved, soon becoming pulverulent; spores subglobose, epispore thin, tuberculate, 12–17 μ; spermagonia rather indistinct, few, mostly on upper side, yellow.

On *Aster sagittifolius:* Jackson, April 21, 4212, 4214, April 25, 4282; Union, April 24, 4253, April 28, 4382; Pulaski, May 1, 4402, May 5, 4501, May 10, 4588; Johnson, May 11, 4613; McLean, May 20, 4723. *Aster sps.:* Jackson, April 25, 4285; Pulaski, May 5, 4510; Johnson, May 12, 4646; McLean, July 7, 2423, July 15, 5558. On *Solidago latifolia:* 4248, 4284, 4732, 4994. On *S. cæsia:* 4249, 4485, 4574, 4506, 4614, 5556. *S. rigida:* 4837 (only spermagonia). *S. altissima:* 4250, 4575, 4587, 4615, 4665, 4688, 4809, 5253. *Solidago sps.:* 4050, 4137, 4166, 4175, 4197, 4283, 4308, 4401, 4425, 4426, 4484, 4528, 4647, 4687, 4733.

Schweinitz at first separated those on *Solidago* under the name *Æ. solidaginis*, but subsequently united them with the *Aster* forms. His change in the form of the specific name to *asteratum* is not followed.

There seems to be a different *Æcidium* on *Solidago*. See Ellis' North American Fungi, No. 1018.

Æ. compositarum.

Under this head are united all the *Æcidia* on *Compositæ* except the two foregoing, whose teleutoforms are doubtful. It is impossible to satisfactorily determine them until full life histories are worked out. It is even impossible to give in this place a description of the species properly known as *Æcidium compositarum*, Mart., neither is it deemed wise to try to refer anything to the Schweinitzian species, *Æ. helianthi-mollis* and *Æ. tracheliifoliatum*. Taking the host plants as guide to a considerable extent, the following *forms* are noted:

On *Eupatorium.* Hypophyllous. Spots distinct, usually few, conspicuous, yellow; æcidia irregularly clustered or somewhat circinate, short, irregularly split and moderately recurved, soon pulverulent; spores subglobose, epispore rather thin, minutely tuberculate, 18–20 μ; spermagonia several, scattered, above, honey-yellow. On *Eupatorium perfoliatum:* McLean, July 11, 2424.

On *Silphium:* Hypophyllous, and often also epiphyllous. Spots distinct, usually widely scattered, not large, yellow, æcidia irregularly associated, scarcely crowded, deeply immersed, and but slightly projecting above the raised epidermal border, margin many times split or pulverulent, little excurved; spores subglobose, often angular, 11–15 μ; spermagonia rather few, conspicuous, reddish brown, central, on both sides of leaf. On *Silphium integrifolium:* McLean, May 3, 4852. *S. terebinthinaceum:* McLean, May 30, 4825, June 23, 5274, July 2, 2420, July 11, 2421. *S. laciniatum:* McLean, June, coll. C. A. Hart.

On *Ambrosia:* Hypophyllous. Spots large, often confluent, scarcely thickened, yellow or purplish brown; æcidia not closely crowded, irregularly distributed over the spot, with, however, a free central area, short, but not deeply immersed, firm, the coarsely divided border widely and elegantly excurved; spores subglobose, usually angular, epispore firm, smooth, 12–15 μ; spermagonia few, central, on both leaf-surfaces, reddish brown. On *Ambrosia trifida:* Champaign, June.

On *Xanthium:* Hypophyllous, very rarely also epiphyllous. Spots not large, distant, scarcely thickened, yellowish, sometimes tinged purple; æcidia not densely crowded, irregularly distributed or subcircinate, mostly irregular in outline, deeply immersed and protruding little above the raised epidermal border, the margin pulverulent, rarely lobed and excurved; spores subglobose or elliptical, often angular, epispore rather thin, minutely tuberculate, about 15–18 μ; spermagonia few, central, mostly above, minute, yellowish brown. On *Xanthium strumarium:* Champaign, June. This is much like the form on *Silphium*, and answers in some respects to *Æ. verbesinæ*, Schw., and also to *Æ. trachelifoliatum*, Schw., but it is probably neither. The *Æcidium* is often followed by *Puccinia xanthii*, Schw., and may be connected therewith.

On *Helianthus:* Hypophyllous, rarely also epiphyllous. Spots distinct or confluent, usually yellow, somewhat thickened; æcidia subcircinate, not usually densely crowded, short, not deeply immersed, deeply split and widely recurved, at first firm, but soon becoming pulverulent; spores subglobose or elliptical, epispore thin, minutely tuberculate: spermagonia few, central, mostly on upper side of leaf, inconspicuous, yellowish brown. On *Helianthus sps.:* Union, April 24, 4256, 4257, April 26, 4309; Jackson, April 28, 4369; Pulaski, May 9, 4573; Johnson, May 12, 4642, 4643, 4644, May 15, 4689.

There seem to be two species on *Helianthus*, and in No. 4644 on the same host. In one case the æcidia are in large clusters, with spores about 12–14 by 13–16 μ; in the other case the clusters are small, and the spores measure about 15–21 by 20–24 μ.

On *Bidens:* Hypophyllous, very rarely also epiphyllous. Spots mostly rather large, effused, often confluent, purple, scarcely thickened; æcidia sparsely scattered, rather prominent, border abruptly and rather conspicuously recurved, firm; spores subglobose, epispore thin, minutely tuberculate, 15–17 μ; spermagonia few and inconspicuous, mostly central, below, often altogether wanting. On *Bidens frondosa:* Adams, June 27, 5304; Champaign, midsummer.

On *Lactuca:* Hypophyllous. Spots definite, conspicuous, thickened, mostly widely separated, but sometimes numerous and somewhat confluent, purple, then brown; æcidia mostly crowded around a free central space, rather numerous, short, many times irregularly split and widely recurved or pulverulent; spores angular, irregularly subglobose or broadly oval, epispore thin, minutely tuberculate, 15–18 μ; spermagonia rather numerous, scattered centrally above, large, simply convex, reddish brown. On *Lactuca Canadensis:* McLean, May 20, 4720, May 23, 4748, 4759, May 25, 4781, 4781½, May 26, 4798, May 29, 4803, May 30, 4826, May 31, 4849, 4865, June 1, 4884; Champaign, June 8, 4894.

Æ. plantaginis, Ces.

Amphigenous. Spots usually small, sometimes effused and large; æcidia collected in little groups or loosely scattered,

short-cylindrical, little or not at all recurved; spores subglobose or elliptical, tuberculate, 18–21 μ; spermagonia seldom found, mostly preceding the æcidia, scattered over the spot on either side of leaf.

On *Plantago Virginica:* Union, April 15, 4106, 4126, April 17, 4134, April 26, 4305, April 27, 4333; Jackson, April 19, 4180, April 28, 4361; Johnson, May 13, 4667.

The determination of this species was made from the specimen in Ravenel's Fungi Americani, No. 483.

Æ. lysimachiæ, (Schl.) Wallr.

Hypophyllous (also on the petioles). Spots distinct, yellowish, scarcely thickened; æcidia somewhat circinate, short, the recurved border very narrow; spores subglobose, epispore thick, conspicuously tuberculate, 21–24 by 22–27 μ; spermagonia few, central, above.

On *Lysimachia ciliata:* McLean, June 1, 4882.

The above description is taken from specimens on *Lysimachia ciliata*, and agrees, save in the irregularly circinate arrangement of the æcidia, with the specimens in Rabenhorst's Fungi Europæi, No. 391. A specimen from Wisconsin on *L. lanceolata* is distinct, especially in the characteristics of the spores, but otherwise as well. It is not known what the Schweinitzian *Æcidium lysimachiæ* is. If the same as Schlectendal's *Caoma lysimachiæ*, the second authority for the name should be Schweinitz; if different, the question arises as to which name shall be allowed to stand. At all events there does not seem to be good reason for writing, as is sometimes done, *Æcidium lysimachiæ*, Lk.

Æ. pentstemonis, Schw.

Hypophyllous. Spots definite, purple, yellow-bordered, usually small, somewhat thickened; æcidia clustered, short, the deeply recurved border rather coarsely split; spores subglobose, inconspicuously tuberculate, 18–21 μ; spermagonia few, central in the spots on both sides of leaf.

On *Pentstemon pubescens:* Union, April 16, 5014 (Earle), April 17, 4138; Johnson, May 12, 4645, May 16, 4698.

Æ. lycopi, Gerard.

Hypogenous. Spots circular, distinct, or more or less confluent, scarcely thickened, purplish brown; æcidia on the leaves mostly circinate, often in a single circular row, sometimes, by the confluence of the spots, loosely and irregularly scattered, on the petioles and stems irregularly crowded, short, recurved border abrupt and much torn; spores subglobose, epispore thin, tuberculate, 15–19 μ; spermagonia few, centrally clustered above, reddish brown.

Spots yellow; subiculum more or less thickened; peridia short, scattered or crowded, margin crenate; spores pale yellow.—Peck, 26 Rep. N. Y. Mus., p. 78.

On *Lycopus Europæus:* Pulaski, May 2, 4424.

Differs from Gerard's description in the arrangement of the æcidia, and less swollen spots.

Æ. myosotidis, Burrill.

Hypogenous. Æcidia uniformly distributed over the leaf, mostly somewhat densely crowded, rather large, somewhat prominent, the recurved border wide and rather coarsely divided; spores subglobose or elliptical, epispore thick, conspicuously tuberculate, 15–18 by 18–22 μ; spermagonia numerous, uniformly scattered over both surfaces of the leaf, reddish yellow.

On *Myosotis verna:* Union, April 12, 4026, 4029, April 13, 4067, April 17, 4132, April 26, 4306; Jackson, April 27, 4343, April 28, 4364.

The distribution of the æcidia is decidedly different from that of *Æcidium asperifolii*, Pers., as described, as well as from the specimens at hand, and similarly different from those named *Æcidium lycopsidis*, Desv., *Æ. lithospermi*, Thüm., and *Æ. symphyti*, Thüm. The three last are made synonyms of the first by Winter, and all are said to be the æcidia of *Puccinia rubigo-vera*. The latter is common in Illinois in wide areas where *Myosotis* does not occur, and no other species of *Borraginaceæ* has been observed infested with the *Æcidium.*

Æ. hydrophylli, Peck.

Hypophyllous. Spots conspicuous, distinct, yellowish; æcidia subcircinate, short, recurved border rather wide and

deeply divided; spores subglobose, epispore thin, smooth or nearly so, 18–21 μ; spermagonia numerous, scattered over the central area of the spot above.

Spots small, few, yellow, with a pale greenish border; subiculum thickened, whitish, peridia few, generally crowded, short, the margin subcrenate; spores bright yellow or orange; spermagonia central, on the opposite side.—Peck, 26 Rep. N. Y. Mus. p. 78.

On *Hydrophyllum appendiculatum:* McLean, July 20, 5600.

Æ. polemonii, Peck.

Hypophyllous. Spots usually distinct, yellowish brown, border effused; æcidia irregularly clustered, usually about a free central area, short, recurved border wide and rather coarsely divided; spores subglobose or elliptical, often angular, epispore thick, conspicuously tuberculate, 18–21 by 21–25 μ; spermagonia few, central, on both surfaces.

Spots suborbicular, pallid or greenish-yellow, sometimes confluent; peridia hypophyllous, crowded, short; spores globose or subelliptical, bright orange, .0008–.001 of an inch in diameter, minutely rough; spermagonia central on both sides of the leaf.—Peck, Bot. Gaz., Vol. IV. p. 230.

On *Polemonium reptans:* McLean, May 29, 4807. *Phlox pilosa:* McLean, May 31, 4851.

Æ. solani, Mont.

Hypogenous. Æcidia uniformly, usually densely, distributed in patches over the leaf-surface, short, friable, soon becoming pulverulent; spores subglobose or elliptical, often angular, epispore rather thick, obscurely tuberculate, 13–15 by 15–21 μ; spermagonia very abundant, hypophyllous, scattered over extended patches with or without æcidia, comparatively large, honey-yellow.

On *Physalis viscosa:* Urbana, Ill., May 30 (A.D. 1879), T. J. Burrill.

There is a *Puccinia physalidis*, Peck, from Colorado, of which the above may be the æcidial form, but so far as known the *Puccinia* has not been collected east of the Mississippi.

Æ. apocyni, Schw.?

Undeveloped.

On *Apocynum cannabinum:* McLean, June 14, 4977.

Æ. Jamesianum, Peck.

Amphigenous, on the leaves more abundant beneath. Spots circular, distinct, or often confluent, on the leaves somewhat, and on the stems much swollen; æcidia subcircinate or irregularly crowded, short, pseudoperidium fragile, soon becoming pulverulent; spores subglobose or elliptical, epispore very thick, conspicuously and densely tuberculate, the tubercles often united in short irregular ridges, 21–36 by 24–45 μ, usually about 30 by 39 μ; spermagonia numerous, scattered or centrally clustered above, nearly black.

On *Asclepias Cornuti:* McLean, May 26, 4799, June 1, 4886, June 19, 5264, June 23, 5277, July 14, 5535, July 17, 5582.

Occurs on stems, petioles and midribs, forming swellings, and on both sides of the leaf, being most plentiful on the lower surface. It is very destructive, eating holes in leaves and stems. The spores are very remarkable for size, marking and thickness (5 μ) of epispore.

There is a different *Æcidium* on *Asclepias Cornuti,* specimens of which were received from E. W. Holway, Decorah, Iowa, labeled *Æ. Jamesianum.*

Æ. fraxini, Schw.

Hypogenous, occurring especially along the veins and upon the leaf-stalks. Spots definite, swollen, often purple; æcidia more or less densely clustered, few or many, elongate, cylindrical, tardily lacerated, but ultimately deeply split and recurved; spores elliptical, epispore thin, tuberculate, 21–24 by 24–32 μ; spermagonia rather numerous, scarcely elevated, on the upper side of leaf, scattered over central area of the spot.

On *Fraxinus viridis:* Champaign, June 8, 4915, June 10, 4954; LaSalle, June 21, 5252; McLean, June 24, 5279, July 5, 2427.

Æ. pustulatum, Curtis.

Hypogenous. Spots small, reddish yellow, thickened; æcidia rather densely crowded, often in a small circle with a vacant centre, short, rather finely split and recurved; spores subglobose, inconspicuously tuberculate, 16–21 μ; spermagonia few, yellowish, epiphyllous, difficult to make out.

Spots small, yellowish, sometimes stained with red, thickened, often concave above, convex below; peridia short, subcrowded, often forming a circle about a free central space; spores pale orange, subglobose, .00066–.00083 in. in diameter.—Peck, 23 Rep. N. Y. State Mus., p. 60.

On *Comandra umbellata:* McLean, May 20, 4717, May 25, 4782, May 29, 4804, May 30, 4827, 4850; Champaign, June 10, 4955.

Æ. euphorbiæ, Gmel.

Hypophyllous. Æcidia uniformly scattered over the entire surface, short, the narrowly recurved border soon becoming pulverulent; spores subglobose to oblong, often irregular and angular, epispore rather thick, tuberculate, 12–15 by 15–24 μ; spermagonia scattered among the æcidia or none, not found on the upper side of leaf.

On leaves of *Euphorbia polygonifolia:* Ravenswood, near Chicago, Oct. 11, 1883, J. C. Arthur. *E. hypericifolia:* Adams, June 29, 5350, July 6, 5430; McLean, July 7, 2432, July 27, 2431, Oct. 6, 1801; Tazewell, July 22, 2430; Piatt, Aug. 27, 1106. *E. maculata:* Kane, Aug. 30, 1374; McHenry, Sept. 1, 1414; Boone, Sept. 2, 1420; LaSalle, Sept. 16, 1548, 1549; Rock Island, Sept. 21, 1617, Sept. 24, 1651. *E. dentata:* Adams, July 6, 5428; Ogle, Sept. 26, 6182.

This occurs with *Uromyces euphorbiæ* in Nos. 1064, 1548, 1616, 2353, and 5428. The genetic connection has not been ascertained for our plants.

Persoon is often given as the authority for this name, but in his Syn. Fung., p. 211, he refers to Gmelin as the author. *Æ. Euphorbiæ-hypericifoliæ*, Schw., is probably a synonym.

Æ. crotonopsidis, Burrill.

Hypogenous, occurring upon the cotyledons, and less commonly on the caulicle and lower leaves. Spots distinct, dark-

colored, the affected cotyledons soon yellow; æcidia not numerous, irregularly clustered, short-cylindrical, becoming coarsely divided and widely spreading, pseudoperidium thin but firm; spores irregular, mostly elliptical, epispore rather thick, tuberculate, 12–15 by 15–18 μ; spermagonia very few, scattered, above.

On *Crotonopsis linearis:* Johnson, May 12, 4648, May 13, 4662, May 16, 4701.

Æ. urticæ, Schum.

Hypophyllous. Spots distinct, brown, border yellow; æcidia densely clustered, short, the narrow border abruptly turned, finely divided; spores subglobose, epispore rather thin, sparsely tuberculate, 15–21 μ; spermagonia minute, scattered, on the upper side of spot, reddish brown.

On *Urtica:* Warsaw, Ill., June 27, coll. C. A. Hart.

Æ. smilacis, Schw.

Hypophyllous. Spots large, circular, somewhat effused, pale yellowish, somewhat thickened; æcidia irregularly scattered or crowded, short, recurved border wide and rather coarsely divided; spores irregular, mostly angular, elliptical to oblong, epispore thick, conspicuously tuberculate, 15–18 by 18–22 μ; spermagonia rather numerous, scattered, mostly above, honey-yellow.

On *Smilax herbacea:* Ravenswood, near Chicago, June 29 (1883), J. C. Arthur.

Æ. trillii, Burrill.

Hypophyllous. Spots distinct or somewhat confluent, circular, effused, yellowish; æcidia densely aggregated around a free central circular space, sometimes with a more or less distinct outer circle later in development, short, pseudoperidium thin, fragile, soon after opening becoming pulverulent; spores subglobose, epispore very thin, smooth, 19–24 μ; spermagonia very numerous, rather prominent, scattered, central, on both sides of leaf.

On *Trillium recurvatum:* Union, April 24, 4251.

Differs from *Æ. convallariæ* in the more fragile and fugacious æcidia, and in the smooth, very much thinner epispore.

Æ. convallariæ, Schum.

Hypophyllous. Spots distinct, or more or less confluent, lemon-yellow, scarcely thickened; æcidia loosely clustered, irregular or subcircinate, short-cylindrical, recurved border narrow and abruptly turned; spores subglobose or oval, sometimes angular, epispore thick, conspicuously tuberculate, 21–24 by 24–30 μ; spermagonia numerous, scattered over the central area of the spot on both surfaces, dark reddish brown.

On *Smilacina:* McLean, May 26, 4797. *S. stellata:* McLean, June 1, 4885; LaSalle, June 19, 5224. *S. racemosa:* McLean, May 31, 4861, 4862.

RŒSTELIA, Rebent.

Spo.es one-celled, in chains or vertical rows, without pedicels; sorus enclosed in an elongated, usually tapering, pseudoperidium, which protrudes far through the ruptured epidermis of the host, and which becomes deeply split and fringed; with spermagonia. On species of *Pomeæ.*

Æcidia usually hypophyllous, lower part sunk in the swollen tissues of the leaves, forming above cylindrical, conical, or oblong projections, which are often split and fringed in the upper part, peridium composed of large colorless cells, spores brownish or orange-colored, subglobose when mature, formed in moniliform rows. Spermagonia punctiform, forming minute dark-colored pustules in discolored spots on the upper surface of the leaves. Mycelium infesting the leaves and stems of different *Pomeæ.*—Farlow, Gymnosporangia of the U. S. p. 24.

The forms included here are now supposed to be (like those of *Æcidium*) mere stages of development of other teleutosporous species, and perhaps all belong to *Gymnosporangium.* The genetic connection of the forms placed in these two genera was first shown by Oersted, of Denmark, in 1865, who satified himself, by artificially sowing the spores, of the relationship existing. His conclusions have since been confirmed by DeBary in Germany, Cornu in France, and Cramer in Switzerland; but nothing conclusive has been ascertained in our country save from the effects in nature of the proximity of the different hosts and their parasites. Professor Farlow's artificial cultures (The Gymnosporangia of the United States, p. 32, etc.) gave not only

negative results, but served to throw doubt upon previous conclusions. In Illinois one species only of *Gymnosporangium* has been collected (from *Juniperus Virginiana*), and wherever this has been observed near apple orchards the latter have been strikingly infested with *Rœstelia*. Unfortunately the specific type of the latter — from anatomical characteristics — cannot be confidently given at the time of this writing. It seems to be *R. lacerata*.

R. lacerata, (Sow.) Fr.

Æcidia hypophyllous, sometimes on the stems and young fruit, seated on the yellow pulvinate thickening of the leaves, slender, cylindrical or somewhat subulate, recurved, densely clustered, 5–30 together; peridia yellowish white, rather delicate, soon splitting and becoming fimbriate, the divisions not extending to the base of the peridium: cells of peridium narrow, 20 μ broad by 55–72 μ long; spores brownish, roundish-oblong, surface finely granulated, 19–24 μ in diameter. Spermagonia in yellowish spots on the upper surface of the leaves. (Farlow, Gymnosporangia of the U. S., p. 30.)

On leaves of *Cratægus tomentosa:* Lee, Sept. 8, 5715; LaSalle, Sept. 13, 1509; Union, Oct. 31, 2141. *C. tomentosa*, var. *mollis:* Piatt, Aug. 17, 1122; LaSalle, Sept. 13, 1510, Sept. 13, 1528; JoDaviess, Sept. 18, 5980; Ogle, Sept. 26, 6193. *C. tomentosa*, var.: Piatt, Aug. 17, 1113; LaSalle, Sept. 12, 1472. *C. coccinea:* Kane, Aug. 30, 1385.

R. penicillata, (Sow.) Fr.

Same as *R. lacerata*, but æcidia smaller and frequently concentrically arranged, peridia splitting to the base, the divisions very numerous, revolute, fimbriate, formed of one or more rows of cells. (Farlow, Gymnosporangia of the U. S., p. 30.)

On leaves of *Pyrus coronaria:* Tazewell, July 22, 2433, 2436; McLean, Aug. 1, 2435; Champaign, Aug. 13, 1042; Piatt, Aug. 16, 1082; McHenry, Aug. 20, 1161, Aug. 27, 1334; Lee, Sept. 8, 5714; Stephenson, Sept. 13, 5838; LaSalle, Sept. 14, 1522; JoDaviess, Sept. 15, 5910; Rock Island, Sept. 23, 1631.

PERIDERMIUM, LINK.

Spores one-celled, in chains or vertical rows, without pedicels; sorus inclosed in a variously-shaped pseudoperidium, which protrudes through the ruptured substratum and bursts irregularly; with spermagonia. On *Coniferæ*.

This so-called genus is composed of probable æcidioforms of *Melampsora*, *Chrysomyxa* and *Coleosporium* species. The mycelium is, however, perennial in the bark and medullary rays of coniferous trees, from which the fruit-form may be annually produced during seventy or more years,—the parts of the host in the meantime becoming variously deformed, and the growth more or less seriously reduced.

Not yet observed in Illinois.

ENDOPHYLLUM, LÉVEILLÉ.

Spores one-celled, produced in chains or vertical rows, without pedicels, the sorus inclosed in a pseudoperidium immersed in the substratum; with spermagonia.

This genus was at first separated from *Æcidium* only on account of the immersed pseudoperidia, which, unlike those of the latter genus, do not protrude through the ruptured epidermis to form a separate cup-like organ; but later investigations have shown that the spores in germination emit a true promycelium bearing sporidia, altogether similar to the germination-development of the teleutospores of *Puccinia* and the other genera of *Uredineæ*. The mycelium in the newly affected plant survives the winter and fruits the next spring.

No species yet observed in Illinois. They may be looked for on various species of *Crassulaceæ*, and perhaps on those of *Euphorbiaceæ*.

GLOSSARY.

Æcidioform, æcidiostage, the first of the alternating fruit forms of numerous species of Uredineæ.

Æcidiospores, the spores of æcidia.

Æcidium (pl. *æcidia*), a generic name; also the cup-like organ characteristic of the genus.

Amphigenous, produced on various parts of a plant, especially on both sides of leaves.

Apiculate, furnished with an apiculus.

Apiculus, a short terminal point.

Ascus (pl. *asci*), a spore sack or case, formed of a single cell, from the protoplasm of which the spores are produced.

Bullate, puckered or crinkled; said of leaves in which the veins seem too short or too near together for the intervening substance.

Capitate, having a somewhat globular head.

Cauline, pertaining to the stem.

Circinate, coiled like a watch spring, often used to indicate a circular arrangement.

Clavate, gradually thickened upward, club-shaped.

Confluent, united, running together.

Constricted, pinched or drawn in.

Cotyledons, the seed-leaves of plants.

Cuneate, cuneiform, wedge-shaped.

Echinulate, closely beset with little sharp-pointed prickles.

Effused, poured out, spreading.

Epigenous, produced upon or above, usually used synonymously with epiphyllous.

Epiphyllous, on the upper side of leaves.

Erumpent, breaking out, or bursting through.

Exsiccati, dried specimens.

Ferments, living organisms capable of changing, by their processes of nutrition, the chemical composition of organic substances.

Ferruginous, rust-colored.

Fimbriated, fringed.

Flavescent, growing yellow, yellowish.

Fugacious, early falling off.

Fuscescent, approaching fuscous or dark brown.

Fuscous, dark brown.

Globose, nearly spherical.

Grumulose, like clustered grains.

Host, the supporting plant, that upon which a parasite lives.

Hyaline, glass-like, transparent.

Hymenium, fruit producing surface.

Hypha (pl. *hyphæ*), a filament of a fungus. The vegetative hyphæ taken in quantity are called the mycelium.

Hypogenous, produced below.

Hypophyllous, growing from the under side of leaves.

Innate, growing inside or inclosed.

Laciniate, cut-fringed.

Lutescent, pale yellow.

Mucronate, abruptly pointed with a spine.

Mycelium, the vegetative filaments of fungi.

Nuclear, pertaining to a nucleus.

Nucleus, a differentiated portion of the protoplasm of a cell.

Pallescent, approaching pallid.

Pallid, of a pale undecided color.

Papilla, a small obtuse protuberance.

Papillate, covered with papillæ.

Paraphyses, sterile elongated organs bordering a sorus, or distributed among the spores.

Parasite, one living upon and drawing its sustenance from another.

Parasitic, having the characteristics of a parasite.

Parenchyma, a tissue of thin walled cells, mostly somewhat spherical.

Parenchymatous, composed of parenchyma.

Pathogenic, disease producing.

Pedicel, a foot stalk, the stem of a spore.

Peduncle, a stalk, sometimes used for the stem of a spore, but more commonly as the main stalk of a flower or flower cluster.

Peridium, a wrapper or covering. The membranous vessel inclosing the spores in *Æcidium* is usually called a pseudoperidium, but for brevity the former is sometimes used.

Pilose, thinly covered with hairs which are long and weak.

Promycelium, the germinal filament of a teleutospore upon which sporidia are borne.

Pseudoperidium, a false peridium, the cup of *Æcidium*.

Pseudopodia, false feet.

Pulverulent, powdery, covered with dust.

Pulvinate, cushion-like.

Punctate, dotted.

Recurved, bent backwards or outwards.

Reflexed, bent abruptly backwards or outwards.

Reticulately, in a net-like manner.

Rufous, red-brown.

Saprophyte, a plant living on dead organic matter.

Septate, divided by one or more partitions.

Septum (pl. *septa*), a partition wall.

Sorus, a spore cluster, or sometimes a cluster of spore cases.

Spadiceous, a bright clear brown.

Spermagonia, minute cysts or capsules containing spermatia.

Spermatia, exceedingly minute bodies produced like spores, and probably under certain circumstances capable of germination, produced in spermagonia.

Spores, a general term applied to the reproductive bodies of cryptogamous plants, differing from a seed in having no embryo.

Sporidia, reproductive bodies borne upon a promycelium, or as sometimes used, the spores produced in asci.

Sterigma (pl. *sterigmata*), foot-stalks of spores, usually applied to those of very minute size.

Striæ, longitudinal lines or marks.

Striate, having striæ.

Subiculum, the modified tissue of the host penetrated by the mycelium of a parasite.

Subulate, awl-shaped.

Teleutoform, the last or final fruit-form in the alternating generations of *Uredineæ*.

Teleutospore, the last spore of a series, the final spore.

Testaceous, brick-color, brownish yellow, orange yellow with much gray.

Tubercle, a small obtuse prominence.

Turbinate, top-shaped.

Uredo, a generic name, also one of the fruit-forms of *Uredineæ*, next before the teleutospore.

Uredoform, *uredospore*, see *Uredo*.

Verrucose, covered with little warts.

Vertex, the upper extremity, here applied to the whole top of a spore, while apex designates the point only.

μ, one thousandth of a millimetre, about one twenty-five thousandth of an inch.

I., II., III., the first, second and third forms of the fungus: or æcidium, uredo and teleutoform.

ERRATA.

Page 142, line 18 from bottom, for insiduous read insidious.

Page 163, line 12, for **Rudbeckiæ** read **rudbeckiæ**.

Page 167, line 7, for 25–23 μ read 25–32 μ; line 15, for **spharganii** read **sparganii**; line 5 from bottom, for **erytheronii** read **erythronii.**

Page 169, line 10, for **acuminatus** read **acuminata.**

Page 172, line 1, for *circea* read *circææ;* line 3, for Cda. read Car.; for *aculeata* read *podophylli;* line 4, after *flosculosorum* insert Roehl.

Page 173, lines 5 and 6 from bottom, for parenchymentous read parenchymatous.

Page 175, line 18 from bottom, for densey read densely.

Page 179, line 15 from bottom, for *Proserpinacea* read *Proserpinaca;* line 9 from bottom, for 24–66 μ read 24–36 μ.

Page 180, line 4, for marked read naked.

Page 181, line 5, for 23–45 μ read 30–45 μ; line 18 from bottom, for *Æcidum* read *Æcidium;* line 3 from bottom, for **Kuhniæ** read **kuhniæ.**

Page 182, line 10, for *eupatoriodes* read *eupatorioides.*

Page 183, line 4 from bottom, for 25 read 24.

Page 184, line 9, for 169 read 180.

Page 198, line 9 from bottom, for **phragmites** read **phragmitis.**

INDEX TO HOST PLANTS.

INDEX TO SPECIES.

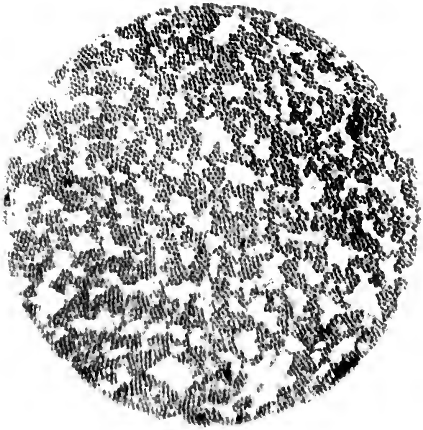

FIG. 1.

FIG. 2.

Culture of MICROCOCUS from diseased Cabbage Worm (*Pieris rapæ* L.), in test tubes of sterilized beef broth, commenced October 20, 1883 (see p, 275). Preserved over winter in plugged test tube, and slides mounted April 10, 1884, in carbolized water, after staining with brown aniline.

Photographed with lamplight by Dr. H. J. Detmers, with Spencer $\frac{1}{10}$ homogeneous immersion, $\times$ 1000.

Both figures are from different parts of the same slide, differing only in focal adjustment,—figure 1 being a "positive," and figure 2 a "negative."

Article IV.—Studies on the Contagious Diseases of Insects.—I.

By S. A. Forbes.

Since August, 1883, the writer has used such opportunities as came in his way for observation of the diseases of insects, and for more or less careful and systematic work upon them, directed especially to the point of artificially propagating them for the destruction of injurious insect species. While these researches are not by any means completed, lacking especially critical study of the bacterial forms dealt with, as botanical species, and imperfect also on the side of field experiments on a large scale, I have thought them worthy of present report as a contribution to progress on a difficult but interesting subject, especially as opportunity for further continuance of some of these studies may not soon return.

My main object has been experimental and economical, and I have adopted such methods of study as seemed to me to offer the simplest means of surely ascertaining whether some of the common diseases of our insects were of bacterial origin, whether their germs were readily and conveniently cultivable, and whether such cultures could be used to convey the original affections to healthy insects.

This will serve to explain what may seem to some an excessive reliance on fluid cultures,—much more convenient for my purpose in these preliminary studies than "solid cultures" with gelatine films or tubes, and quite conclusive as to the identity of the forms dealt with, if the cultures are often enough repeated and the results are closely scanned.

Without attempting at this time to summarize the literature of the subject,—scattered and chiefly fragmentary, except as relates to the silkworm and the honey-bee,—I give here only a brief account of my own earlier notes and observations.

The appearance of what seemed to be an epidemic of contagious disease among the chinch bugs of Central Illinois in the latter part of the summer of the above year, gave rise to an article on this subject, published in 1883 in my first report as

State Entomologist of Illinois (pp. 45–57). This article contained an account of a considerable series of microscopic observations on the fluids of chinch bugs apparently affected with disease, and described some successful attempts at the culture of the Micrococcus found invariably characterizing this insect affection. Time failed for further experiments, and the chinch bug has since been so scarce in my vicinity that no further opportunity has offered to complete the study of the subject. The observations made amounted to a practical demonstration of the occurrence of a "germ disease" in this insect species, identified the germ as a Micrococcus, since described as *Micrococcus insectorum*, Burrill, and proved that this was easily and freely cultivable in beef broth. The Micrococcus was shown to have its seat in the alimentary canal of the insects, occurring most abundantly in the posterior part of the same, to infest pupæ and adults more seriously than the younger stages, and to have the apparent effect to retard the development of the brood as well as to destroy a large percentage of them before they reached maturity. This disease was apparently the representative of *flacherie* or *schlaffsucht* in caterpillars, as described by previous authors and in the following pages.

Next there appeared early in August, 1883, in our breeding cages of *Datana ministra* (the yellow-necked apple caterpillar), an outbreak of disease characterized by the occurrence, at first in the alimentary canal and later in the blood, of immense numbers of micrococci of a form very different from the above, and evidently quite readily conveyed from one insect to another. Elaborate studies of this disease were made during the remainder of the season and the following spring, the bacteria associated with it were repeatedly cultivated with success in animal infusions, and several experiments were made to convey the disease by their means to still healthy larvæ. Tubes of the culture fluids were sealed up for preservation over winter, their contents were cultivated again in June, 1884, and the resulting cultures were used to infect the food of larvæ of *Mamestra picta*, with the hope of thus reproducing the original disease of the Datana larvæ of the preceding year.

Parallel with these experiments was a similar series made on a frightfully contagious and destructive disease of the European

cabbage worm (*Pieris rapæ*), first observed by us at Normal, September 11, 1883. The bacterial character of this disease was ascertained, many attempts at cultures were made, some of them successful, and the possibility of conveying the disease to a distance by means of affected cabbage worms was tested by us in Western Illinois and Iowa. Many of the observations and experiments relating to *flacherie* in this insect were repeated by me in 1884, and in the early summer of 1885 admirable photographs of several of the slides were made for me by Dr. H. J. Detmers, of Champaign.

"Jaundice" of the silkworm appearing in an experimental nursery of this species, under the charge of Professor Burrill at the State Industrial University, at Champaign, in June, 1884, an opportunity was afforded me to study this affection. Many successful cultures were made of the bacteria involved, and several experiments were undertaken for the infection of healthy cabbage worms with the contagion from these artificial cultures. Succeeding in the laboratory, these experiments were carried into the field, and attempted on the large scale of actual practice.

An epidemic of muscardine appearing in certain breeding cages of the forest tent-caterpillar (*Clisiocampa sylvatica*) in June, 1884, this disease was studied by us as there illustrated, and connected more or less certainly with a destructive epidemic of the preceding year, which had swept away vast numbers of that species under my observation in Southern Illinois.

With the exception of the *flacherie* of the chinch bug, these observations have not hitherto been anywhere fully reported, although brief notices and general accounts of a more or less popular character have been printed in the scientific journals and in some economic publications.

The chinch bug observations were published, as already mentioned, in the Twelfth Report of the State Entomologist of Illinois, the species of Micrococcus concerned having been previously described by Prof. Burrill in the Report of the Trustees of the Illinois Industrial University for 1882, and in the "American Naturalist" for March, 1883.

A brief preliminary paper on *flacherie* of Datana was read to the entomological club of the American Association for the

Advancement of Science at its Minneapolis meeting in August, 1883, and of this a synopsis appeared in the "Canadian Entomologist" for September, 1883. In the "Prairie Farmer" (Chicago) for October 6, 1883, and in "Science," also, for October 5, 1883, brief notes occur with reference to this disease in the cabbage worm.

In the Transactions of the Illinois State Horticultural Society for 1883 (printed February, 1884) is a somewhat elaborate paper on the Contagious Diseases of Caterpillars, read before this Society December 18, 1883, giving a general and rather popular account of the character of the work done by me on this subject, up to that time; and a still more elaborate paper (never published) was read before the State Natural History Society of Illinois, at its meeting in Peoria, July 8, 1884, in which a classification of insect diseases was presented, and a full *résumé* of methods and results, up to that date, was given. At a meeting of the State Horticultural Society, held at Champaign, December, 1884, I added some further items relating to cultures and experiments, especially those affecting the cabbage worm, and these notes were published in April, 1885, in the Transactions for the year preceding.

It is my purpose, in this paper, to present the principal results of the above studies,—both the successful and the unsucessful issues,—the latter so far as they have any significance or value.

Disregarding the chronological order of my observations, I shall first discuss *flacherie* of the cabbage worm, and jaundice of the silkworm, with experiments upon the former insect with the artificial cultures derived from the latter. I will then take up the longer and more complicated record of *flacherie* in our Datana larvæ and the experiments drawn from it, and will conclude with a brief account of the *muscardine* of the forest tent-caterpillar.

EUROPEAN CABBAGE WORM *(Pieris rapæ, L.)*

In studying experimentally an insect disease, it is necessary, in the present state of our knowledge, (1) to determine precisely the symptoms and character of the disease itself, in order that it may be subsequently recognized with certainty; (2) to

learn whether it is characterized by bacteria; and (3) whether it is practically contagious. Determining these questions affirmatively, (4) cultures of the bacteria must be made artificially, and (5) these cultures must be used to produce, in healthy insects of the same or other species, a disease characterized by the symptoms and results of the original affection. It is further desirable that (6) second cultures should be prepared from these cases of disease artificially produced, in order that a strict comparison may be made of the bacteria concerned, as they occur both in the bodies of the insects and in artificial culture fluids.

I propose to take up these points *seriatim*, (first with respect to *flacherie* in the cabbage worm), presenting separately the facts bearing upon each, only premising that the proof of one proposition is sometimes partly contained in the data relating chiefly to another, so that some repetition will be necessitated by this mode of discussion; but this disadvantage will doubtless be found insignificant, compared with the gain in clearness and cogency.

Description of Flacherie in the Cabbage Worm.

In this insect *flacherie* is distinguishable with great ease and certainty by conspicuous external symptoms, the color alone of affected larvæ being, in fact, entirely characteristic and unmistakable. The natural color of a healthy cabbage worm is a light lively green, sometimes slightly tinged with yellowish, but without any approach to an ashy or milky hue. As the first symptom of *flacherie*, however, the larva commences to turn pale, this paleness increasing more or less rapidly until the color is almost milky white, only slightly tinged with greenish. This discoloration is uniform and simple, no other tint usually appearing until after death. Then, however, the color deepens to a sooty gray, commonly uniform, but sometimes appearing first about the center of the length of the larva. Occasionally this deeper color appears a little before death, but it is not then of equal depth over the whole surface.

In the actions of the insect there is little to indicate any change of state, except a gradually increasing sluggishness,

slowness of movement, and loss of appetite. These are later to appear than the pale discoloration above mentioned, and even shortly before death a larva may show considerable impatience if roughly handled. When the disease is well developed, the caterpillar is very feeble, and will remain motionless for a long time; or if it attempt to crawl where some strength is needed, as horizontally on a vertical surface, it may lose its hold with its jointed limbs and cling only by its central prolegs, the fore and hinder parts hanging limp and helpless at right angles to the remainder of the body.

Most commonly an escape of fluid from the vent is among the earlier symptoms of the affection, at first greenish or whitish, and later a dirty gray, or even a chocolate brown. Rarely this fluid exudes also from the mouth. The amount of it is usually sufficient to stain considerably the surfaces over which the larva crawls; but sometimes this symptom is wholly absent. Occasionally the stomach is found empty after death, but almost invariably it is well filled with food, much of which has not yet lost its native color, digestion being, in fact, evidently suspended during the course of the disease. I have found in only a single instance an appearance of bubbles of gas in the alimentary canal, such as Pasteur describes in the *flacherie* of the silkworm. Usually the mass of the alimentary contents seems to lie inert in the stomach, undergoing neither digestion nor decay.

The color of the fluids of the healthy larva is a very pale transparent green, the blood containing only lymphoid corpuscles in greater or lesser number; but if a proleg of a diseased specimen be snipped off, and a cover glass be pressed against the cut surface, the droplet exuding will be of almost milky whiteness, or, in the latest stages of the disease, a dirty gray. Rarely, where there has been much escape of fluid from the vent, the juices of the larva will be thick and scanty, so that it requires some pressure to force out a very small quantity. If a minute droplet of the milky fluid obtained by snipping off a proleg be examined under a high power of the microscope, it will found to contain innumerable myriads of very minute spherules, varying in diameter, according to the individual, from .5 μ to 1 μ. Usually their average size does not surpass .7 μ. It is

the infinite multitude of these which gives to the fluids of the diseased caterpillar their milky look, and likewise, unquestionably it is they which cause the ashy appearance of the surface, the skin being thin and delicate, so that the color of the fluid contents shows through. The diseased blood is so thick with these minute corpuscles that little else can be ordinarily seen in it. Sometimes, however, degenerated lymphoid corpuscles of the blood will be noticed, recognizable by their size and spherical contour, but differing from the normal corpuscles in their darker tint and coarsely and irregularly granular structure. These darker, granular corpuscles are always dead, no longer exhibiting amœboid movement, and have usually a spherical form. Not infrequently *débris* of the fatty bodies is apparent in the form of large irregular cells, floating freely in the fluid, but these cells themselves will be found to contain immense numbers of the minute spheres already mentioned. In fact, if a little portion of the soft remnant of the fatty bodies be removed, spread upon a cover, and examined with a power of a thousand diameters, it will be seen that the cells of these organs are the seat of an extreme degeneration, the entire contents of many of them being wholly replaced by the spherical granules mentioned above. Occasionally a cell containing a nucleus will be found, but more commonly all distinction of contents has disappeared.*

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* As an example of the condition of the fatty bodies, I will describe those of a larva examined October 9, whitish in color and nearly dead, making little effort to escape. A droplet of the blood exuding from a small cut made in the back was alive with the minute spherules already mentioned, and contained also noticeable numbers of dead blood corpuscles in a dark, spherical, granular condition, together with a few unaltered examples still capable of amœboid movement.

A fragment of the fatty bodies examined. consisted chiefly of pale spherical cells, 1.5μ to 7.5μ in diameter, resembling oil globules, except that they had not the high refractive index of fat. A few of these globular cells were very pale and indistinct, the contents very indefinitely granular and often with a large spherical nucleus likewise very pale; but most of them were more or less completely filled with dancing spherules, slightly different in size in different cells, these differences having, however, no relation to the proper size of the cells. Sometimes there were not more than twenty-five or thirty such granules in an optical section of a large cell, the con-

If the body of a diseased larva be cut across and a cover glass be pressed against the cut end of the intestine, or, still better, if the larva be opened lengthwise, the stomach removed and laid open separately, so that a droplet of the pure contents of the alimentary canal may be obtained, the fluid portion of these contents will be seen to swarm with infinitesimal granules identical in appearance with those found in the blood, except that they are, on an average, often appreciably larger and are occasionally more or less oval in outline. These same forms may also be found in the fluid excreta escaping from the vent of the still living larva. If the specimen has been dead some time, so that the sooty discoloration of the surface has occurred, the fluids both of the alimentary canal and of the body at large will often be found to contain, besides myriads of the above spherules, various other forms clearly recognizable as septic bacteria,—among these, members of the genus Bacterium, easily distinguishable by their oval form and by the manner in which they actively propel themselves across the field of the microscope. Rod-like bacilli may also appear in the fluids at this time, equally active, and evidently moving by means of flagella, especially in the vicinity of the bubbles of air which may be included in the fluid under the cover glass. Occasionally these latter bacterial forms may be found in smaller numbers even before death, very rarely in the perivisceral fluids, but not very uncommonly in the contents of the alimentary canal. Still they are infinitely less abundant than the Micrococcus-like spheres already mentioned, even long after the death of the larva.

The most characteristic *post mortem* phenomenon is the rapid softening, decay, and deliquescence of the body, the whole of which may be converted, in an hour or two after death, into a dirty fluid mass which the rotten skin is barely sufficient to hold together. This breaks at a touch, allowing the fluid contents to escape.

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tents being otherwise fluid. Many of the cells were not full, areas occuring which the dancing particles did not invade. Occasionally an unaltered nucleus would be seen in the midst of the corpuscular contents of the cell. The fat globules intermingled were easily distinguished from the above cells by their very different refracting power, and were always free from the spherical granules. They were less than half as numerous as the pale cells. The average size of the granules was not far from .66 μ.

The Characteristic Bacteria.

As implied in the foregoing, I have no doubt that a large percentage, at least, of the minute spherical granules abundant in the fluids of the body and alimentary canal of the diseased larvæ are genuine bacteria, belonging to the genus Micrococcus I cannot hope to convey verbally the same conclusive conviction of this fact which I have myself derived from long study of these little forms under a great variety of conditions, and the preparation and examination of a multitude of slides, both recent, and permanently mounted. These latter were sometimes unstained, and again stained with a considerable variety of aniline dyes,—brown, blue, violet, and magenta. Several successful cultures have also assisted to confirm this view, the products of the cultures being unmistakably the form originally taken from the caterpillars under experiment.

In form the micrococci of the cabbage worm are usually strictly spherical, although in the alimentary canal a patch will occasionally occur in which they are of a slightly oval outline. The micrococci of the fluids of the diseased larvæ seen in the field of the microscope are mostly separate spheres, but a considerable percentage of them are attached in pairs, as if in process of division. Rarely a short chain of four, six, or eight may be seen. In the stomach they occur not infrequently in compact patches or zoöglœa-like masses. In size the individuals vary from .5 μ to 1.25 μ in diameter, the small forms being those in the blood and the larger those in the stomach. Individual larvæ differ, in fact, with respect to the size of their micrococci, in some the average of those found in the blood being not far from .75 μ to 1 μ, while in others they barely reach .5 μ. Commonly, those of the stomach average 1 μ.

In addition to the direct evidence above adduced, the close resemblance of these corpuscles to those occuring in other larvæ affected similarly to the cabbage worm, in which the bacterial character was even less obscure, gave indirect and cumulative evidence with respect to the nature of those forms in the cabbage worm. Their reaction to the usual staining fluids was such as the hypothesis of their bacterial character

would require. Although staining with some difficulty, many slides were prepared in which the individual bacteria were beautifully stained and distinctly differentiated from an uncolored film, by brown aniline, methyl violet, and magenta.

Although several of the attempts at artificial culture were abortive, and although the cultures resulting were sometimes impure and occasionally doubtful, enough cases of unquestionable success occurred to give full effect to this mode of proof. The details supporting this statement will be given under another head. It is worthy of special remark that in no case did the beef broth in which these cultures were made, although it became densely milky with bacteria, give off the slightest smell of decomposition. Only a faint, indescribable odor was perceptible, but little different from that of the fresh liquid.

To the above we may add the association of these spherules with diseased conditions and with *post mortem* phenomena which could scarcely be accounted for at all, except on the supposition of the bacterial character of these excessively abundant forms.

The proof of the contagious character of the disease in question, next to be adduced, must also be taken as indirect, or, at least, *prima facie* evidence, in the present state of our knowledge, of the living organic character of these multitudinous particles,—the only forms present which could in any way be connected with the disease as agents of the contagion.

Contagious Character of the Disease.

Most of the considerations brought forward in the preceding section apply with some force to the subject of this, for if the fluids of the diseased and dead larvæ swarm with micrococci so minute (these appearing in the blood long before death), and if these are shown to escape from the body by way of the excrement and the fluids exuding from the vent, the presumption is strong that the disease which they characterize would be conveyed to healthy individuals by their instrumentality. But we must look for proof of contagion chiefly to the conditions of the occurrence of the disease, to the phenomena

of its spread, and especially to the results of experiments for conveying it artificially to localities or regions where it had not before appeared.

That this affection, or one very similar to it, attacks the cabbage worms of the old world, is made likely by a chance remark in Curtis's "Farm Insects" (p. 96), where he says of several larvæ of an allied species, *Pieris brassicæ:* "On the 20th they appeared healthy, but inclining rather to a yellow color: it rained during the night, and on looking at them in the afternoon of the following day, I saw they had removed to a leaf, to which they stuck by four of their hinder legs, and, to my surprise, they were of a dirty color, and rotten, the skins being lax, and lying just as the wind blew them about. I found they only contained some cream-colored fluid, a portion of which was scattered upon the leaves."

In this country the disease seems to have been first noticed in the vicinity of Washington, in 1879, although little attention was paid to it, and its bacterial character was not then ascertained. In Bulletin 3, of the United States Entomological Commission, (pp. 69, 70), Dr. Riley remarks, while discussing some experiments made with yeast on the cabbage worm:

"An incident connected with these experiments which I made is, however, well worthy of being mentioned, because it shows how very easily single experiments may lead to false hopes and conclusions. A certain proportion of the last-named larvæ — the proportions differing in the different lots treated — perished before or while transforming to the chrysalis state. They became flaccid and discolored, and after death were little more more than a bag of black putrescent liquid. I should have at once concluded that the yeast remedy was a success, had I not experienced the very same kind of mortality in previous rearing of this larvæ, and had I not, upon returning to the field from which the larvæ in question were obtained, found a large proportion similarly dying there."

No other notices of it have occurred in my reading, previous to those of its appearance in Illinois, already mentioned (October 5, 1883). That it did not occur at Normal in 1882 is made certain by the fact that the cabbage fields there were frequently visited in autumn by myself and my assistants dur-

ing the progress of a series of experiments with insecticides upon the cabbage worm, and that nothing of the sort was seen by us.

When first noticed there, its distribution was peculiarly irregular. In certain small fields, for example, not one half mile distant from those in which the disease was raging violently, affecting one fourth to one half of the worms in sight, not a single dead larva could be found by very careful search. A few weeks later (October 4), larvæ in these fields were suffering as severely as the others, 20 per cent. of the worms, on an average, showing signs of illness.

September 27, at Rosehill, near Chicago, I visited fields in which, although the worms were fairly abundant, I could not find a single diseased larva during a careful examination of more than a hundred individuals; while across a road and a half mile away, the disease was fully at work in four adjacent fields, and fully one fourth of the worms had been attacked. These were in all stages of the disease, many of them being dead and rotten. The identity of the affection with that observed at Normal was established by careful microscopic examination.

From correspondents to whom I had described the cabbage worm mortality at Normal, I received various reports. Prof. A. J. Cook, of the State Agricultural College of Michigan, wrote me, October 2, that about 10 per cent. of the cabbage worms near Lansing were affected by it. On the other hand, Prof. Lintner, State Entomologist of New York, informed me, November 3, that it had not been noticed with him. Dr. E. R. Boardman, in Stark county, sixty miles northwest of Normal, reported, September 29, that the cabbage worm was there very destructive, but that no appearance of the disease in question was discoverable. October 5 he repeated this observation, but on the 13th of that month he finally found a very few affected larvæ.

D. S. Harris, of Cuba, in Fulton county, nearly south of Dr. Boardman, first wrote me on the 13th of October that no disease had appeared among the cabbage worms about his place, nor at adjacent towns, as he had learned by careful search and inquiry, but on the 25th of the month he wrote: "That disease

attacking the cabbage worm has made its appearance in Cuba at last. On the 21st I found one full-grown worm sick (head downward), and in about five hours it was dead and decomposed, and several others were affected. To-day it is a difficult matter to find a sound worm on the plants, while the remains of dead worms are numerous."

From Prof. G. H. French, at Carbondale, and Mr. Frank Earle, at Cobden, I learned that the disease had not appeared in Southern Illinois as late as October 29, nor did it occur there during the season. From Champaign, east of me, Prof. Burrill wrote me, October 25, that he had not yet seen any of it in his small garden patch of cabbages, although watching carefully for it; but that an intelligent student had described it as occurring in fields near the town.

In Iowa, to the westward, it seems not to have occurred spontaneously that year, the only appearance of it noted by Prof. Osborn, of the Agricultural College of that State, being the result of an experiment, the material for which I furnished him from Normal. Wherever it once occurred it continued to prevail throughout the season, as far as our observations went.

The facts clearly and positively negatived the supposition that there was anything in the weather or local conditions to explain either the presence or the absence of the disease, and all bore out the hypothesis of a gradual progress from the east westward. The same phenomena of irregular local distribution were manifest the next year (1884). In certain large fields almost daily observed, it was impossible to find a single diseased larva at a time when, half a mile away, the cabbage worms of small patches had been almost wholly destroyed, their blackened bodies, or the shriveled remnants of the same, being scattered everywhere on the leaves.

I may say, incidentally, that the effect of the epidemic in limiting the ravages of the worms, was very evident last year. For the first time in several seasons large fields of late cabbage were brought to full maturity without the loss or serious damage of a head.

From the foregoing the conclusion is unavoidable that all the circumstances of the natural occurrence and spread of the disease are consistent with the hypothesis of its contagious character, and wholly inconsistent with any other.

Two attempts were made to convey the contagion by means of diseased larvæ to localities not reached by it,—one lot being sent October 3, to Dr. Boardmam, at Elmira, and one to Prof. Osborn, at Ames, Iowa. The experiment of Dr. Boardman was not wholly satisfactory, for the reason that through an unfortunate delay of the package the worms which I sent him did not arrive until October 22, at which time the disease had appeared spontaneously, in a small way, in his vicinity. Nevertheless he selected, October 23, two lots of twenty-five worms each, all perfectly healthy to appearance, fed them regularly, but exposed all of them to the contagion by enclosing them in two boxes with the dead and sick caterpillars which I had sent him. At the same time he secured ten healthy larvæ in a box by themselves and kept them free from infection. The latter lot all pupated without accident, but were not followed further. The first two lots commenced to show symptoms of disease on the fifth day, and by the eighth day all of both lots were dead, except three, only one of which finally reached pupation. Even this pupa, in fact, afterwards died and decayed. By this time, however, the disease was so violently raging in the open fields that no great value can be attached to this experiment, especially as the fluids were not microscopically examined.

The material sent Professor Osborn, of Iowa, including dead and dying worms and a mounted slide of the micrococci, arrived October 5, and two cabbage heads were at once infected. On the 7th one of the worms "had evidently succumbed to the disease." The gathering of the cabbages under observation during the temporary absence of Prof. Osborn necessarily interfered with the further progress of the experiment, but he collected such worms as he could from the stumps and fed them in confinement. A number of these larvæ died, and December 28 he wrote me that he had "found micrococci in a number of sick and dead cabbage worms, which must certainly have taken the disease from the ones sent."

Although these experiments, taken alone, could scarcely be regarded as conclusive as to the contagious character of *flacherie*, taken in connection with the other facts mentioned, we must at least allow them some weight as cumulative evidence.

Artificial Cultures of Bacteria.

Methods of Culture.—The modes of culture used in all the experiments reported in this paper were based, unless otherwise specified, on those of Klein, as described in his paper "On the Relation of Pathogenic to Septic Bacteria," in the Journal of the Royal Microscopical Society for January, 1883, differing only by modifications which will appear in the description. The cultures were usually made in beef broth (rarely in infusion of cabbage) in test tubes plugged with sterilized cotton, or in ordinary flasks similarly closed. The broth was prepared by boiling lean beef from a half hour to an hour in a porcelain-lined vessel, and then filtering and carefully neutralizing with caustic soda. The tubes, flasks, and cotton were sterilized by heating in a tin oven, over a gasoline stove, for several hours, at a temperature of not less than 275 degrees or more than 300, as determined by a thermometer inserted in the oven. The heat was sufficient to considerably scorch the cotton without actually charring it. While still within the hot oven the tubes and flasks were securely plugged by means of steel forceps freshly heated in the flame of an alcohol lamp, the cotton plugs, from two to three inches in depth, being pushed firmly in. Most frequently the mouths of these plugged vessels were covered with a cap of sterilized cotton, held in place by an inverted beaker also carefully sterilized by dry heat. In charging the vessels with the fluids the plugs were rapidly withdrawn and as promptly returned, the infusions being introduced boiling hot and afterwards boiled for several minutes to destroy any germs which might have entered during the instant before the plug was replaced. It was not found necessary to test the sterilization of the tubes by protracted incubation, as all the check tubes and the stock flasks in which the store of prepared infusion was preserved, remained unchanged throughout the entire season. Neither was any incubator required, the ordinary temperature of the air during the weeks when these experiments were in progress being never below 60° by day, and ranging commonly above 70° both day and night.

When a culture tube or flask was infected with the fluids of a larva, the following process was invariably used. From

small glass tubes, about a quarter of an inch in diameter, pipettes were made in the flame of an alcohol lamp by drawing out each end to a capillary filament, the tips being closed by melting at the time of making. To charge these pipettes, the end of a proleg of a caterpillar was usually cut off with sterilized scissors, the point of the capillary tube broken off with forceps just flamed in an alcohol lamp, one of these points pushed into the cavity of the proleg, and the pipette partially filled by exhaustion of the air from the other end. To introduce the droplet of fluid so obtained into the test tube we invariably, removing first the beaker and the cap of cotton contained within it, carefully forced down through the cotton plug the capillary tube of the pipette containing the infection material, without loosening at all the plug itself. Sometimes the tip of the tube containing the fluid was broken off inside the test tube before the withdrawal of the pipette, at other times the contents were carefully forced out with the breath, pains being taken not wholly to expel the fluid contents of the pipette. After withdrawal of the tube, the cotton plug was grasped with sterilized forceps and slightly twisted within the mouth of the test-tube to close effectually any small opening through the plug which might have been made by the introduction of the pipette. After this the cap of cotton and the beaker glass were restored, and the tube was set aside with a companion precisely like it in all respects, except that it had not been infected. During the latter part of our investigations these check tubes were themselves operated upon with capillary pipettes, distilled water only being introduced, at the time that the experimental tube was infected.

In withdrawing portions of the products of the culture for inspection a similar process was used, the freshly made pipettes being introduced as for infection and partially filled by exhausting the air from the upper end. After withdrawal, the cotton plug was again twisted as already described and the cap returned. The cover glasses used in the examination and preparation of the material, whether this was derived directly from the larvæ or from artificial cultures, were flamed with an alcohol lamp immediately before using, after being thoroughly cleaned by rubbing with a linen cloth. Slides were similarly

treated for study with the microscope. A droplet of the fluid was allowed to flow from the tip of the pipette upon the cover glass, spread in a thin film by means of the capillary glass tube, and either placed at once upon the slide for immediate examination, or laid aside under a glass shade to dry. After drying, if it was desired to stain and permanently mount the specimen, the cover with the film attached was passed repeatedly through the flame of an alcohol lamp, covered for some minutes with a drop of the staining fluid (the glycerine aniline colors recommended by Prof. T. J. Burrill*), and then thoroughly washed with distilled water. The covers thus prepared were often mounted in balsam, but most frequently, at first, in carbolized water in very shallow cells made with white zinc cement, this cement being also used to fasten the covers to the slides. For microscopic study of the material, my principal reliance was a superb $\frac{1}{10}$-inch homogeneous immersion objective, made to order for the purpose by Herbert R. Spencer & Company, of Geneva, New York. This objective was used with Bulloch oculars, giving powers ranging from 500 to 1,450 diameters. Some of the more interesting or difficult slides were also studied under a $\frac{1}{18}$-inch homogenous immersion of Zeiss.

The measurements here reported were originally made by means of an eye-piece micrometer so graduated that with the highest powers used, each space equalled 2 μ, the micrococci being commonly measured in doubles and chaplets. Many of these measurements were verified by repetition with a more finely divided micrometer, the spaces of which, with a power of 1,000 diameters, had a value of .3 μ; but practice with the more coarsely spaced scale enabled me to measure as accurately with this as with the other, and with much greater convenience.

The products and results of the fluid cultures were commonly so satisfactory that I rarely resorted to solid cultures upon gelatine films. A few of these were made, however, but not with the micrococci of the cabbage worm; and they will be described under the head of the Datana larvæ. As I was primarily interested only in the disease and secondarily in the bacteria, cultures on films were less essential to my purpose

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* Proceedings Amer. Society of Microscopists, 1883, p. 79.

than if I had wished to discriminate and describe the various forms appearing. I depended upon frequent repetition of the experiments and uniformity of results, rather than upon the more critically exact cultures and continuous observation of current methods with gelatine films and masses.

Culture Experiments.—Concerning our first cultures, the fact should be remembered that one could rarely expect to find a perfectly pure culture in the body of a diseased insect, exposed as it is by way of the food ingested to invasion by bacteria in great variety. I consequently did not find it remarkable that several of our unquestionably sucessful *infections* were not really pure *cultures*, other bacteria developing than those most abundant in the original fluids. For example, in the very first culture made,—one in beef broth begun September 16, when the infection process was very carefully managed without the slightest accident, and when the check tube remained clear indefinitely,—the culture became turbid the following day, and by October 3, was nearly as yellow as cream, with a thick yellowish felt on top and an abundant precipitate. The greater part of the product of this culture consisted of micrococci like the larger of those of the cabbage worm, the spherules, in singles and doubles, averaging 1 μ in diameter; but the surface film consisted largely of a Saccharomyces embedded in the Micrococcus. Individuals of Bacterium also occurred in the slides. The check tube, as already mentioned, was quite clear to the end.

The second culture was still less conclusive and satisfactory. A cabbage worm which, on the afternoon of the 17th September, was noticeably paler than its companions, was isolated and watched. At 9 p. m. it seemed a little stupid, but otherwise unchanged. At 9 a. m. of the 18th, however, it was dead, blackened, and very soft, the contents evidently little better than fluid. These fluids contained two micrococci,—one a larger spherical or slightly quadrate form, 1 μ in diameter, and the other a minute spherule .5 μ to .75 μ.

A small flask of rather weak beef infusion was infected from these fluids in the usual manner, and the next day, the 19th, it was already decidedly milky. Examined, it was found to contain Bacterium and the larger Micrococcus above men-

tioned, a slender Bacillus, and another Bacillus-like form, of which there will be further question hereafter, a short, broad form with rounded ends and a paler center, but nothing resembling the smaller Micrococcus. These organisms were quite possibly all septic bacteria, derived from the decaying body of the caterpillar.

The first unmistakable culture of the Micrococcus of the cabbage worm was made October 20, in a test tube of beef broth infected from the blood of a larva about half grown, decidedly pale, but far from dead. The slide representing the blood of this larva is not stained, but is in good condition. There were two bacterial forms visible in it, a spherical Micrococcus .7 μ in diameter, and, very rarely, a slender Bacillus. The flask in which the culture was made was poured from a stock flask into a sterilized tube from which the plug of cotton had just been removed, plugged again, boiled thoroughly about three minutes and left to cool completely. The blood was obtained by snipping the skin of the back with sterilized scissors, and drawing up with a fresh pipette a little of the thick fluid exuding. The tube was infected in the usual manner, and not examined until two days thereafter, when it was found decidedly turbid, although not extremely so. The Micrococci were strictly spherical, 1 μ in diameter, very uniform and abundant, usually in doubles, but often single. The slides made were excellent and well stained, some violet and some brown. The bacteria differed from their originals only in being somewhat larger. Still they were not larger than the Micrococcus of the cabbage worm is often found, especially in the intestines. The check flask remained wholly clear.

Four other successful cultures of this Micrococcus were made, so similar in all respects to the preceding that it is not worth while to repeat details. It must be admitted, however, that the minute blood form did not certainly reappear in its *original size* in any of my cultures, if we except one case where its numbers were relatively so few (about 100 to the field with a power of 1,000) that it is barely possible that all were introduced in the original infection. This fact is capable of either one of three interpretations: (1) We may suppose that the proof is incomplete that these smallest spherules from the blood

were micrococci at all, notwithstanding their uniform shape, size, and character, and the fact that they were repeatedly distinctly stained; or (2), taking for granted their bacterial nature, we may suppose them insusceptible of culture under the conditions supplied; or, finally (3), we may assume that the conditions of tube culture in beef broth were so different from those occurring within the blood of the insect as to increase the size or even modify the form of the Micrococcus in question. In favor of the latter hypothesis we have the fact of the generally larger size and often slightly oval form of the micrococci found in the intestinal fluids, as compared with those in the blood of the same specimen.

These considerations apply, however, only to the minute blood form, and not at all to the intestinal Micrococcus. This I have cultivated repeatedly with indubitable success in this insect, and, still more frequently, forms indistinguishable from it occurring in other species. I venture to add that the frequency with which certain bacteria, different from the infection material, appeared in the test tubes when these were infected from the cabbage worm, suggested repeatedly the hypothesis of an alternation of certain forms which were in this way frequently connected,—a point on which I shall have more to say when describing the Datana bacteria. Especially was this true of the larger Micrococcus and of the short, broad Bacillus (?) with pale center and rounded ends (here called, for convenience, *Bacillus intrapallens*). The latter, I shall presently show, behaved precisely like a pathogenic form,—giving no odor of putrefaction in fluids swarming with it, killing insect larvæ whose food was treated with it, and certainly multiplying for some days within their living bodies.

The late period at which successful cultures of the cabbage worm Micrococcus were made precluded attempts at artificial infection by their means, and with respect to this particular insect this part of the proof is consequently wholly wanting.

When the evidence is given respecting the reproduction of what was clearly the same disease in other insects, I think that no reasonable doubt will remain that *flacherie* of the cabbage worm may be conveyed through artificial cultures of its Micrococcus.

THE SILKWORM *(Bombyx mori, L.)*

Late in July, 1884, I heard from Professor Burrill, of the State Industrial University, that a lot of silkworms which were being reared under his direction for experimental purposes were dying rapidly from an apparently contagious disease resembling the *flacherie* of the old world, and wishing to improve the opportunity thus afforded to determine the possibility of conveying this affection to our native Lepidoptera, I had, July 30, some of the dead and dying larvæ sent me by mail from Champaign. From our correspondence at the time and from an account of the experiment by Prof. Burrill, published in the Twelfth Report of the Board of Trustees of the Illinois Industrial University, 1884, we learn that the lot of worms (about 80,000 in number) in which this disease broke forth were raised from eggs derived from a perfectly healthy brood of the preceding year ; that they commenced to hatch June 21 ; that they were kept in a clean and thoroughly ventilated building set aside for their use on the University grounds ; that they began to spin July 25 ; that between this date and the 29th 183 cocoons were produced, but that in consequence of the outbreak of this disease among them only a single additional cocoon was made during the season. The entire remainder of the 80,000 worms perished,—commencing to die July 23, and continuing until the latter part of August.

Description of the Disease.

In a note of July 23, Prof. Burrill says of the affected larvæ that they "become yellow, shorten up; the skins become very tender so that they can hardly be picked up without bursting; body flaccid; the blood loses its clearness and becomes thick with a dirty yellowish color." Again, July 26, he writes: "They first refuse food and uneasily creep around, then become yellowish and flabby."

In the article above cited, Prof. Burrill distinguishes two forms of disease among the larvæ, as follows:

"In one case the affected larvæ became restless, ceased eating, the skin assumed a decidedly yellowish tint and ulti-

mately became very tender and easily ruptured, while the blood, unusually copious, was thin and yellow instead of its normal limpid or grayish color. Other larvæ became sluggish, continued to eat, but consumed only a small quantity of food, the body gradually became flaccid, the skin wrinkled and tough, and the color a grayish or leaden tint, and finally nearly black. These, hours or even one or two days before their death, adhered by their prolegs, or some of them, to a support, and remained quiet, at length only showing signs of vitality when touched, and at last dying while still firmly anchored to the limb or other object upon which they rested. After, and for some time before, death, the flaccid body hung directly downward from the point of attachment. If this latter happened to be near the middle of the body, the two ends hung down, the parts nearly parallel with each other. From these dead and blackened worms a decided and characteristic odor of putrescence was perceptible, tainting, when numerous, the air of the well-ventilated room."

The first of these diseases was also characterized in the Statistical Record of the State Board of Agriculture for August, 1885, by Mr. Woodworth, who conducted the experiment for Prof. Burrill. "This disease," he says, "does not make its appearance until the worms are about ready to spin, that is, near the end of the last age. The body of the affected worms assumes a somewhat granular, yellow color, instead of the natural, bright semi-transparent hue. This change of color also differs from the normal change, in that the yellow is first on the middle of the segment instead of at the ends. The skin becomes soft and tender, breaking at the least fall, and allowing the yellow body fluid to escape more readily than wounds of equal size would in healthy worms. The affected worms become very restless, crawling about and shrinking in size from loss of blood until they finally die. A few spins cocoons, which are generally soft, often bright orange, and sometimes so thin that the pupa or dead worm may be seen within. Some of the worms even pupate without spinning, and from these pupæ moths may emerge, which will sometimes deposit their eggs. When a brood of worms is attacked by this disease generally very few survive."

Several lots of the larvæ were sent me in July and August, representing both the above-described affections, the difference between which was easily discernible. The former disease was apparently that known to the French as *jaunes* (sometimes called jaundice by the English writers and by some considered the same as *grasserie*), and the latter was unquestionably *flacherie* or *morts-flats* of the French — the *schlaffsucht* of the Germans.

The yellow color of the "jaundiced" worms was evidently due to the tint of the blood, and this, again, was as clearly derived from the great numbers of peculiar cellular bodies with which the blood was always loaded, these originating chiefly, if not wholly, in the fatty bodies, as a result of that form of degeneration of those organs in the larva which attends pupation. These bodies, when entire, consisted usually of masses of spheres, each 4 μ or 5 μ in diameter, the aggregate attaining a diameter of 30 μ — 40 μ. The individual spheres often presented a slightly angular outline, as if modified by mutual pressure, and they took no aniline color with which I tried to stain them. These bodies are evidently the mulberry cells and granules of Viallanes, as described in his admirable memoir on the histolysis of insects.* That they originated chiefly in the fatty bodies, I demonstrated by finding masses of them in portions of the fatty bodies themselves and by determining the substantially unaltered condition of all the other tissues of the affected silkworms.

In the blood of these larvæ no bacteria were found, as a general rule, although Professor Burrill occasionally recognized a Bacillus in it; but in the alimentary canal I never failed to discover great numbers of micrococci and often also numerous examples of Bacterium and Bacillus.† These bacterial forms

* Ann. Sci. Nat., Zool., xiv. 1,—Art. 1. August, 1882.

† A transverse section of a jaundiced larva mounted in balsam without staining, shows great numbers of spherical micrococci, somewhat unevenly distributed throughout the entire thickness of the wall of the intestine, and fully as abundant in the outer portion of this wall as within. The same micrococci occur in the perivisceral spaces, being accumulated especially upon the free surface of the organs contained therein. A very few are apparent also in the sections of the fatty bodies, and occasionally in the muscles, but none occur in the skin

were not different from those observed in cases of undoubted *flacherie*, but they were usually far less numerous,—a fact which has suggested to me the following theoretical explanation of the supposed jaundice of the silkworms at the University. Assuming that the mortality was originally caused by the intestinal bacteria, we may suppose that this infection was not sufficiently overwhelming to destroy life by direct action, as seems to be the case in *flacherie*, but that it nevertheless had the effect to so disturb the balance of physiological functions as to retard the development and preparation for pupation of some of the organs, while the fatty bodies, being special stores of material accumulated for use in pupation, and so less promptly and easily affected by causes attacking the general health of the larva, went on to pupation and experienced the histolysis characteristic of that phenomenon. In other words, we may suppose, quite consistently with all the facts, that a relatively slight bacterial attack took *uneven* effect on the various parts of the animal and not immediately destructive effect on any; that it retarded the preparations for pupation of the great vital organs, but that the fatty bodies, as if unaware of this fact, continued their course of maturation and histolysis, reaching a condition of pupal disorganization before pupation had actually occurred.

The condition of the fatty bodies of the larva affected by the supposed jaundice is well illustrated by slide 4732 of our collections, containing portions of the fatty bodies of larvæ received from Prof. Burrill on the 30th July. The cells of these organs, when examined under a power of 500 diameters, were found, nearly all of them, to have undergone a remarkable change. The contents of a few still remained minutely granular, a large nucleus being also occasionally visible, but the con-

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or in the silk tubes. These micrococci are very distinctly visible, shining with a reddish light when slightly out of focus, not being rendered transparent by the mounting medium as are the tissues of the larva. They are arranged in patches and strings, the former of irregular shape, the latter sometimes containing as many as eight or ten spherules. The fatty bodies of this larva are almost solid masses of mulberry granules. The Malpighian tubules of another specimen show also, besides their normal crystalline contents, great numbers of these mulberry granules, formed within the cells or derived from outside sources.

tents of the greater number had been converted into very distinct pale granules, varying in size in the different cells from 2 μ in diameter to 4 μ or 5 μ. About 20 or 25 of the larger size were usually contained in a single cell, and a multitude—too numerous to count—of the smaller ones. Here and there in the area of the object were large irregular lacunæ evidently filled with liquid fat, as shown by the slightly crystalline character of their contents.

Whatever we may assume with respect to the bacteria infesting these worms as a cause of the premature pupal degeneration, I do not know that we have any reason to suppose that they are the only possible cause of such a catastrophe to the insect. Other influences tending to disturb seriously the balance of functions at the critical period when larval life is about to terminate in pupation might not impossibly have the same effect.

Additional details respecting this peculiar catastrophe to maturing larvæ will be given further on, under the head of *Mamestra picta*.

The Characteristic Bacteria.

As an illustration of some of the conditions characteristic of this disease, I give descriptions of well-mounted slides prepared from the fluids of one of the larvæ received from Prof. Burrill on the 30th July. The larva was dead when examined, but perfectly fresh. In the blood I found only the mulberry granules, some free and others still enclosed in their mother cells, as already described, together with blood corpuscles in various stages of degeneration. My notes at the time and a recent examination of carefully prepared slides show that no bacteria occurred in the blood.

In slide 4603, material for which was obtained by touching a cover glass to the cut end of a divided worm, I find great numbers of the mulberry granules, varying in size from 2.5 μ or 3 μ to 6 μ, the more usual diameter being, however, 4.5 μ to 5 μ. With these occurred, everywhere, myriads of micrococci, probably one fifth of the area of the field of the microscope being occupied by them where the film is of moderate thickness. These micrococci vary in form from exact spheres,

usually in doubles, to broad ovals, with the transverse diameter about three fourths the longitudinal, these likewise usually in doubles. Occasionally pairs of doubles are joined end to end in four's, but longer chains than these were not observed. The micrococci frequently occurred upon the slide in patches of fifty to one hundred, in which most of the individuals were seemingly single. The ovals above mentioned have the same transverse diameter as the spheres, differing only in length. This diameter varies but little from .75 μ, although slightly smaller singles are not infrequently found. Many of these small, as well as larger, singles are scattered separately through the field. Besides the ovals above described, occasional ovals larger than these are seen, closely resembling, in fact, *Bacterium termo*, and probably to be considered as belonging to that genus. These are about 1.5 μ in length (doubles 3 μ) by 1 μ in transverse diameter.

In the thicker part of the film very considerable numbers of excessively minute spherules were discernible, deeply stained, .5 μ in diameter, apparently identical with those described under *Pieris rapæ*, on a preceding page*, and clearly the same as those appearing in the culture described on page 286.

The slide from which the above description is taken was deeply stained with methyl violet July 30, and mounted in dammar.

Another slide, 4612, derived from the same lot of worms and similarly treated, differs only in the fact that the micrococci average somewhat smaller; that nearly every one is almost strictly spherical; and that an occasional small Bacillus occurs, 2 μ to 3 μ in length by about .66 μ in width. The ends are broadly rounded, the sides parallel, except in the shorter specimens where they are slightly convex. These bacilli are sometimes single, more commonly attached endwise in pairs. The smaller oval forms, possibly distinct, frequently show a pale center with ends heavily stained.† In this slide are a considerable

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*Is it perhaps possible that the silkworm affection had its exciting cause in the disease of the cabbage worm, which made its first appearance in this region the year before?

† To this form a peculiar interest attaches in some of my other studies, reported on a later page.

number of large, regularly elliptical bodies, about 5 μ in length by 3 μ in transverse diameter. As they do not stain, they are probably crystalline, especially as it is well known that larvæ about to moult or pupate often have the blood loaded with crystals of uric acid of which the form is often not different from that here noted.

As characteristic of the second form of disease, *flacherie*, that distinguishable in the living larvæ by the pale color of the surface as compared with the lemon-yellow of *jaunes*, I have selected slide 4727, derived from the fluids of a freshly dead larva. In the blood of this specimen no bacteria were discernible, but in this slide, prepared from the mingled blood and alimentary fluids, they occur in innumerable myriads. The slides are, however, instantly distinguishable from those derived from the yellow-skinned larvæ, by the complete absence of the mulberry granules. The bacteria from the selected slide are not by any means so uniform as those in the one previously described, but vary from perfectly spherical micrococci to ovals, double ovals, and elongate bacillar rods. The spherical and oval forms of micrococci are, however, the predominant bacteria. The spheres in this slide are commonly wider than the ovals, measuring about .75 μ, while the smaller ovals are not more than .5 μ in their shorter diameter. The spheres vary in arrangement from singles to chains of considerable length, but the latter aggregates may be due to an accidental running together in the drying film. The bacilli are not distinguishably different from those described for the other form of disease. Besides the above, occasional larger broad ovals appear, similar to those doubtfully determined above as *Bacillus intrapallens*. Judging, in short, from this representative slide, one would say that the bacteria of *flacherie* of the silkworm consist of a varied mixture of round and oval micrococci of different sizes, of species of bacteria, and of small bacilli. Some of them, however, may have been of *post mortem* origin. The slide in question is beautifully stained with methyl violet, and mounted in dammar.

Contagious Character of the Diseases.

I had no opportunity to observe the progress of these diseases in the silkworm, but Professor Burrill was entirely confident of their contagious character as exhibited under his observation. On this point he says*: "That the worms came from good eggs, and were, for a considerable time, perfectly healthy and wholly free from the malady which finally overtook them, we have the best of evidence. The disease which carried them off was not hereditary. It was not lurking unobserved during the more favorable weather in the living or dying worms. Its introduction occurred about, and probably at, the time of the first heavy rains spoken of, but we confidently know that it could have been artificially introduced without the rains or the wet weather at all. Moreover, the worms continued to die after the weather cleared up, and after every precaution had been taken to put them under the best possible conditions. We constructed new racks in a room not previously used, picked out the healthiest worms and moved them to the new and clean quarters, where, afterward, the temperature and other conditions were as favorable as could be desired; but the ravages of the disease continued with no perceptible abatement. To further test the matter, other apparently healthy worms, voracious feeders, growing rapidly, were put out upon the open hedge, where they were watched from daylight until dark to keep off the birds, and where, for a time, they seemed to thrive under the favorable skies and wide isolation; but here, too, they gradualiy fell victims to the destroyer. In each of these places about five hundred worms were placed, from which, as was before said, one cocoon only was secured, and this from the out-of-door lot. The latter did live longer than any of the others, but at length as surely succumbed. Another experiment proved equally futile; viz. that of spraying the food with an aqueous solution of carbolic acid. No apparent improvement followed this treatment.

It may be said that our disaster followed in consequence of retarding too long the hatching of the eggs by keeping them in

* Twelfth Rep. of the Board of Trustees of the Illinois Industrial University, pp. 90, 91.

an ice-house, thus pushing the feeding season out of the natural time and subjecting the worms to unfavorable summer heat, or providing them with leaves too far advanced towards maturity. This might, indeed, seem plausible had not several other lots, fed in the vicinity, but not so retarded, died in the same way. It is interesting to note that in some of these small and isolated experiments in silkworm feeding, certain lots from the same kind of eggs as our own, produced from the same lot of moths, fed on the same kind of food, remained perfectly healthy and produced good cocoons, while others totally failed. It seemed that in every case where what appeared to be the disease called in this paper *flacherie* became once introduced, few or none of the worms lived to spin passably good cocoons. Most of them died after the third or fourth moults, and after, therefore, no little care had been bestowed upon them."

My own observations on this phase of the subject were of an experimental character, and will be found in detail under the head of Experiments for Artificial Infection. Here I need only say that they demonstrated the possibility of affecting with disease healthy larvæ of the common cabbage butterfly (*Pieris rapæ*) by means of artificial cultures of the bacteria occurring in the sick silkworms,—these cultures being made in beef broth and applied to the cabbage worms in confinement by sprinkling or spraying their food.

Artificial Cultures.

Our first cultures of the bacteria of the silkworm were made July 30, in test tubes of beef broth, by the methods described above, in my account of the cabbage worm disease, the material for infection having been obtained from a yellow-skinned larva (affected by jaundice) received on the same date from Professor Burrill, of Champaign. The larva used was recently dead, but still perfectly fresh. Two cultures were made, one from the blood and one from the alimentary fluids. No bacteria were discernible in the blood, either in fresh preparations or in mounted films, the latter presenting only numerous and excellent examples of the mulberry cells and granules characteristic of the disease. The slides prepared from the fluids of the alimentary canal, however, exhibit numerous

specimens of a strictly spherical Micrococcus, occurring usually in doubles, measuring 1 μ in diameter, with an occasional oval example apparently elongating for division, and then about 1.5 μ in length. These micrococci stained readily with methyl violet.

In the test tube infected from the blood, curiously enough this Micrococcus reappeared in a perfectly pure culture. The fluid, infected July 30, was seen to be milky on the 1st of August, and many micrococci were visible in doubles and chains, the latter being unusually abundant. On the prepared slides, less heavily stained than the originals from the silkworm, these micrococci measured a little less than those of the alimentary canal, the diameter usually falling between .75 μ and 1 μ, rarely attaining the latter dimension. Chains of six or eight were not uncommon.

The culture derived from the alimentary canal of this larva was unexpectedly impure and not altogether comprehensible. The fluid was observed to be milky August 1, and many micrococci appeared in fresh slides, both in doubles and chains. A perfect film, distinctly stained, but rather pale, shows, however, a variety of forms. Most conspicuous, but not the most abundant, are doubles and short chains of three to six of a strictly spherical Micrococcus, deeply stained, entirely similar to those above described, but averaging smaller, their mean diameter being a scant .75 μ. Besides these are short, broad ovals, a little less deeply colored than the above, of the same transverse diameter, but a fair 1 μ in length, some, indeed, falling scarcely short of 1.25 μ. In addition to these and of the same transverse diameter, we see, rarely, rod-like forms, apparently bacilli, measuring from 3 μ to 4 μ in length; and, finally, thickly scattered, everywhere more abundant than any oval form, are very minute spherules, always in singles (except in now and then an instance seemingly accidental), measuring a scant .5 μ in diameter. These are well stained and conspicuous, and unquestionably do not belong to the film. They are extremely like the smaller form of cabbage-worm micrococci which I have already described. Their appearance under the circumstances suggests the possibility of their being bacillar spores, but the bacilli in the film are far too few to permit this

explanation; nor did any of those noticed seem to be spore-bearing. The impurity of this culture makes the supposition plausible that some of the bacteria of the orignal infection were introduced by accident and not derived from the silk-worm. The check tube, however, remained unaltered, as usual; and it seems to me more likely that the originals of all these forms were really derived from the alimentary canal. It is not to be supposed that the alimentary contents of a larva long diseased, and, indeed, actually dead, should remain wholly free from invasion by bacteria other than those strictly characteristic of its disease.

The cultivation of bacteria from the blood, although none were microscopically demonstrable in the latter itself, seems to me not a remarkable phenomenon (especially as the fluid was derived from a dead larva), since it could scarcely be credible that the circulatory fluids should, under such circumstances, be entirely free from the peculiar germs of the disease to which the larva had succumbed. It must be remembered that a single individual Micrococcus would be sufficient to start the culture in the tube, and that the quantity introduced into the beef broth was much greater than that represented by the films microscopically examined. Furthermore, an occasional Micrococcus in a stained film may readily be overlooked or passed as doubtful, since the difficulty of distinguishing single individuals from accidental granulations of the film itself forbids positive identification of the micrococci unless they occur in numbers sufficient to make their character unmistakable.

Another culture, commenced July 30, from the silkworm 4603, the bacteria from which were described under this number on page 281, was examined August 1, at which time the fluid was observed to be milky and found swarming with micrococci and a few examples of Bacterium (?). (The latter, it will be remembered, were also observed in the original material.) The resultant culture was possibly impure, the two forms appearing on the slides being distinguished, however, only by the positive strong stain of one and the very delicate stain of the other, shapes and sizes not being appreciably different.* That distinctly

*Those lightly stained were probably the empty walls of dead examples.

stained unquestionably agreed in every particular with the common spherical Micrococcus of the original silkworm material, except that it measured a trifle smaller, scarcely averaging 1 μ, although many individuals and doubles were fully that size. This culture was preserved for experiment and used as an infection fluid on the 9th August. The results of this attempted infection will appear under another head.

Still another culture, commenced and examined upon the same dates, yielded an abundance of the spherical Micrococcus most frequently mentioned above, together with occasional examples of a Bacillus 3 μ or 4 μ in length and about 1 μ in transverse diameter. These last were, however, too rare to have any special significance, except as a slight adulteration of the culture.

The next culture attempted, commenced July 31 and examined August 4, is of especial interest, as it resulted in the complete displacement of the normal Micrococcus of the silkworm by another organism present in its fluids (the questionable *Bacillus intrapallens* already mentioned*), but in small numbers.

This culture was made from a silkworm of the original lot received from Professor Burrill, July 30, the beef infusion being infected from a dead worm. The fluids of this larva contained vast numbers of the ordinary silkworm Micrococcus, somewhat under the usual size, averaging, indeed, only about .75 μ. An occasional large Bacillus, 4.5 μ long and 1 μ wide, also occurs on the slides made from this individual. Besides the above is the organism already mentioned, varying in form from a broad oval to a Bacillus-like rod, characterized by a pale center staining little or none, and heavily stained extremities. The culture examined August 4 contained vast numbers of this organism and apparently nothing else. Most of those appearing in the films from this culture were much smaller than the original, all the stages, in fact, appearing, from a simple sphere scarcely, if at all, distinguishable from a Micrococcus, to the

* This organism displaced similar cultures made from the larva of *Datana angusi* presently to be reported on, was preserved through the winter, cultivated the following season, and then applied effectively to the destruction of larvæ of other species.

rod-like form or double elongate oval, the paler centers commencing to appear in the oval and becoming more conspicuous as this elongates.

A single somewhat later culture, commenced August 4, did not differ materially in results from those preceding. No bacteria were discoverable in the blood of the larva, used by prolonged and careful search, but the alimentary fluid contained the usual Micrococcus. Five days later the infected infusion was decidedly turbid, but without either film or sediment. Besides an occasional short Bacillus in active movement, it contained only the spherical Micrococcus of the usual size.

The slides of these various cultures clearly demonstrate the presence of a spherical Micrococcus, varying in diameter from .75 μ to 1 μ, as the characteristic Bacterium of the disease from which these silkworms were perishing, and likewise the practicability of artificially cultivating this Micrococcus in neutralized beef broth by infections from the alimentary canal and from the blood. Although the Micrococcus itself was not demonstrable in the blood by the microscope, it was obtained therefrom by cultures in which it appeared without admixture of other forms. Intestinal cultures were, however, liable to contamination by other bacteria but doubtfully connected with the disease, among which was the form last described.

Infection Experiments.

I found it by no means easy to provide means for testing satisfactorily the possibility of conveying the disease of the silkworm above described to other demonstrably healthy insects. The late period of the occurrence of the disease under my observation made it impossible to use other lots of the silkworm itself in the experiment, and no other lepidopterous larva was sufficiently abundant at the time, except the cabbage worm. This, however, had alread been found, the previous year, to suffer extensively from an extremely destructive disease of its own, and although at the time the experimental stage of my studies of the sick silkworms had been reached, no evidence of disease among the cabbage worms had yet appeared in the fields, I had every reason to anticipate its outbreak among them,—a fact which made me very doubtful of really bringing

the matter to a decisive test on that species. The occurrence of a spontaneous outbreak of the common cabbage worm *flacherie* among the lot under experiment, would of course arrest the progress of the experiment, and might even so mask the result as to mislead.

This accident, in fact, occurred to my first two experiments, begun August 9 and 10. Not only did the cabbage worm affection appear in both the experimental breeding cages and the checks, but the latter lot as well as the former gave evidence of infection from our silkworm material. The latter fact convinced me that my arrangements were inadequate for the protection of my check lots against accidental infection with the experimental material. These lots were placed at a distance from those purposely exposed to disease, but in another part of the same large hall, and were attended by the same assistant. In previous experiments, not yet detailed, with other larvæ, I had already had evidence of slight unintentional infection of the check lots by this too close association with those under treatment, and now arranged another experiment on a wholly different plan.

Careful examination was made of all the cabbage fields near Normal, and one was selected which showed no trace of the proper disease of the cabbage worm. From this field two lots of caterpillars were selected, twenty-five in each, those for experiment by the assistant whose duty it was to make the infections, and the check lot, by an intelligent student of the Normal school, who did not visit my zoölogical laboratory at all. The first lot was brought to the office and placed in a clean and disinfected cage in the usual place, but the second or check lot was taken by the student mentioned directly to his own home and confined in a new breeding cage. Care was taken that both lots should be fed and treated alike, except for the infection, but no opportunity was given for any communication between them. The results in this case were more satisfactory, and confirmed my suspicion that our check lots had not before been sufficiently isolated.

History of the Infected Lot.—The food of the twenty-five cabbage worms selected especially for experiment, was sprayed on the 6th September with beef broth infected nearly a month pre-

viously from the fluids of a silkworm recently dead from jaundice. Unfortunately, from some oversight, neither slides nor detailed notes were made of this culture until the experiment upon the cabbage worms was instituted. The beef broth, nearly a gallon in quantity, contained in a large receiver, the tube of which was closed with a sterilized cotton plug nearly six inches in length, had promptly become turbid, as usual, and was soon opaque with bacteria. By the 6th September the development of the bacteria had apparently nearly ceased, a thick deposit covering the bottom of the jar. The fluids at this time contained vast numbers of spherical micrococci .7 μ to .8 μ in diameter, mostly in doubles, apparently identical with those occurring in the silkworm. The culture, however, which had been several times opened for examination, was not at this time wholly pure, but contained likewise bacteria and large and small bacilli. These occurred, however, in relatively insignificant numbers, and the fluids when poured out presented no odor of putrefaction, but had, on the contrary, only the faint indescribable smell characteristic of the cultures of all our insect bacteria.

After infection on September 6, the cabbage worms were fed with fresh food collected for them daily. Their cage was kept in a large room, before an open south window, was thoroughly cleaned each day, the paper covering the floor of the cage being removed and burned, all the litter and *débris* destroyed, and the larvæ carefully transferred to fresh food upon clean paper.

A single individual died September 8, evidently from accidental injury. Three of the larvæ pupated on the 10th. On the 11th two died, apparently of disease. The fluids of these were carefully examined and found to swarm with micrococci. Of these covers were prepared in the usual form. The first slide, made from the blood, contains large spherical micrococci, nearly all in doubles, 1 μ in diameter, excellently stained with violet. The bacteria of the second slide, representing the contents of the alimentary canal, were more various in form. In addition to the above large Micrococcus, 1 μ in diameter, many slightly double ovals of about the same transverse diameter occurred, together with several .7 μ wide, most

commonly arranged in small groups; occasionally, also, an unsegmented rod, possibly Bacillus. Nothing representing the minute spherical micrococci characteristic of the native disease of the cabbage worm occurred in this specimen. The next day, September 12, one larva pupated and four perished. The first of these examined was already blackened and deliquescent. It contained nothing but large and small micrococci strictly spherical in form, the large one 1 μ in diameter, the other about .6 or .7 μ. Both occurred usually in doubles, but not unfrequently in singles or short chains. Both stained well in methyl violet, and good slides were prepared. The smaller form of the above micrococci was found only in the blood, and the larger only in the intestine, as indicated by the stained slides from these two sources.

The second larva studied was soft and grayish green, but the skin was tougher than usual, and showed little tendency to the characteristic deliquescence of the cabbage worm disease. The fluids were yellowish white, and contained great numbers of large and small spherical micrococci, the larger 1 μ in diameter, the smaller .6 or .7 μ.

The third specimen, smaller than the preceding one, was a little darker in color, the fluids yellowish green and containing identical micrococci. Both forms were spherical and of the same dimensions as those just described. A single Bacillus was also noted, 2.5 μ in length, and an occasional double oval occurs upon the slides (probably Bacterium) each oval element about .8 μ long.

The fourth specimen was flaccid, but bright green, its fluids thick and milky white. It contained a moderate number of large spherical micrococci, identical in appearance with those described above, varying in character from .8 μ to 1 μ. Besides these, the blood was literally loaded with large spheres, evidently mulberry granules, occurring singly and in masses, the diameter varying from 2 to 4 μ. A close correspondence in the condition of this larva to that of the silkworm affected with jaundice will at once be noted.

Four other larvæ, two of which died September 13 and two on the day following, were briefly examined, but not carefully studied. Their fluids presented no considerable differences from

those already treated. On the 15th another larva pupated, and a second died during the night which had been reported sluggish the previous day. The body was shrunken, not very soft, a little brown, but the general color was still the usual green. The fluids of the specimen were very white and thick, and contained vast numbers of mulberry granules, both singly and in clusters, together with great quantities of oval micrococci (some in chaplets of four) and occasional individuals of Bacterium, some of the latter in actual motion. The mulberry granules were strictly spherical, and varied in size from 1.5 μ to 3 μ in diameter.

Another larva which died was originally paler than natural, but not white. Before examination it had blackened and turned very soft, but was not deliquescent. Slides prepared from it contained *débris* of tissues, muscular and other, and vast numbers of minute spherical micrococci from .5 μ to .7 μ in diameter. No flagellar motion was detected in the fresh slides, and no other forms are apparent in the stained mounts.

Another example, small and shrunken, a little discolored, dried up in a few hours, and became hard and brittle. It was not especially studied. On the 17th of the month the last remaining larva died. It was not discolored, and I could find no bacteria in the blood or other fluids. The cause of its death, in fact, was not apparent. At this date a blackened pupa from the cage, evidently not long dead, was found full of a blackish fluid, which contained vast numbers of a small spherical Micrococcus (.6 μ in average diameter, commonly in doubles) and nothing else, except occasional mulberry granules 2 μ in average diameter. Of the individuals which pupated, six emerged successfully, three were deformed, and two failed to complete their transformations.

History of the Check Lot.—This lot, placed in a new breeding cage September 10 with fresh cabbage, was kept under continued observation until the 28th. One of the specimens died the first day from an accidental injury; one pupated on the 12th; and two others were necessarily crushed in opening the cage, having commenced to pupate on its sliding glass front. On the 14th four examples pupated, and two more upon the 15th, at which time fifteen healthy larvæ remained. The more

rapid pupation of these specimens will be noticed, as compared with those treated with the infection material,—a fact consistent with what I have uniformly observed with regard to the effect of these diseases.

On the 17th four worms were drowned in a dish of water containing the food plant in the breeding cage. The fluids of these worms were carefully examined with a microscope, and careful studies were made of stained covers of their blood and alimentary contents, but no possible bacteria of any sort were detected in them. On the 21st three more larva pupated, and on the 23d three died. Unfortunately, the latter fact was not reported by the assistant in charge in time to permit an examination of these dead worms. All the remaining larvæ pupated, the imagos commencing to emerge on the 26th.

Although the results of the foregoing experiments were somewhat less definite than might be desired, yet they clearly indicate the transference of the disease affecting the silkworm to healthy larvæ of *Pieris rapæ.* It would perhaps have been difficult to establish by a study of the bacteria alone any marked difference between the disease resulting from this experiment and that native to the cabbage worm, but the symptoms of the two diseases were so unlike as to make it impossible to confound them. The general absence of the peculiar discoloration of the common *flacherie* of the cabbage worm, and of that rapid *post mortem* deliquescence even more characteristic of it, leave no doubt as to the actual difference between this induced disease and the spontaneous affection. That the artificial disease was identical with that of the silkworm, differing only in such a degree as was to be expected when attacking such widely different larvæ, is rendered probable, not only by all the attending circumstances, but also by the occurrence in the cabbage worm of the myriads of mulberry granules characteristic of the affection in the silkworm. This fact is especially significant, since in all our numerous examinations of the native *flacherie* of the cabbage worm this condition of the fluids was not once observed.

I followed this experiment with a similar one in the field, applying the same fluid to a number of cabbages infected by

the worms and selecting others as a check on those treated, but the appearance in this field, at about this time, of the common *flacherie* of the cabbage worm, and the death, from this cause, of several of both lots of larvæ interrupted the experiment. The general outbreak, also, of the same spontaneous affection of the Pieris larvæ elsewhere in the vicinity, precluded all attempts at a repetition of these field experiments.

THE YELLOW-NECKED APPLE CATERPILLAR.
(*Datana ministra*, Drury.)

On this species my first studies of the bacterial diseases of caterpillars were made in the autumn of 1883. The affection which attracted my attention broke out in our breeding room shortly after the larvæ were collected, but was not seen among the species anywhere in the field. It probably was not different from the disease well known to entomologists who rear caterpillars to the imago, especially liable to appear in close and sultry weather, and when the breeding cages are insufficiently ventilated.

A lot of the larvæ, two or three hundred in number, obtained July 23, was reported to me, August 1, to have been mysteriously dying for several days at the rate of two or three a day. The small room in which they were kept was open to the south by a large window, and breeding cages of ample size were used, so placed as to be well ventilated. The larvæ were fed and the cages cleaned daily.

Description of the Disease.

Except that no change of color was usually perceptible, the symptoms of this disease were not especially different from those which have been already given for the silkworm and cabbage worm. Sluggishness and evident weakness and loss of appetite were the first noticeable phenomena. A larva while resting upon a vertical surface would often partly lose its hold, and hang only by a few of the legs,—this occurring long before the power of active locomotion was lost. As a very common thing a discharge of a brownish fluid from the vent occurred early in the disease, but occasionally this symptom was not

observed. As a consequence of this purging, the body would become soft and flaccid and somewhat shrunken,—an appearance not presented by those in which the purging did not occur. Occasionally some portion of the body, usually the central or posterior part, became darker before death, but much more commonly the larva retained its natural hue. The approach of death was gradual, the affected insect becoming more and more sluggish and insensible to irritation. *Post mortem* changes were neither so rapid nor so extreme as in the cabbage worm, owing probably, in part, to the thicker and tougher skin.

The fluids escaping from the vent were microscopically examined, and found always swarming with bacteria,—many of them not infrequently having the flagellate motion of Bacterium proper, but the greater number of them being clearly Micrococcus. If a droplet of the blood were obtained before death, it rarely gave any evidence of bacterial affection, the only cases in which this was seen being those in which an *ante-mortem* blackening of the body was observed. After death, however, the blood invariably swarmed with the same bacterial forms which were found earlier in the intestine, the ordinary septic species soon developing rapidly. The alimentary canal usually contained, both before and after death, vast numbers of Micrococcus, and also, not infrequently, true Bacterium, but bacilli or other bacterial forms were rarely found. The micrococci occurring were not by any means as uniform as in the cabbage worm and silkworm, both spherical and oval species of various sizes often appearing on the same slides. The intestine was commonly filled with food little, if at all, digested. In only one instance was the alimentary canal empty and partly filled with gas.

The Characteristic Bacteria.

The bacteria which, from their abundance and uniform presence, must be regarded as characteristic of this affection, occurring as they did in the still living larvae almost to the exclusion of other forms, were oval and spherical micrococci,—sometimes one, sometimes the other, and sometimes both commingled in variable proportions. The oval micrococci were

usually in singles and doubles, the spherical ones commonly in doubles and short chains of four to six; in the latter case, often taking on a quadrate form. The ovals varied in length from 1 μ to 1.4 μ, and in transverse diameter from .8 μ to 1 μ. The spherical and quadrate forms were nearly always under 1 μ in diameter, usually averaging about .8 μ. Both forms stained readily with both methyl violet and brown, and occurred frequently in patches or colonies in the intestinal canal.

I mention here a point of especial interest in relation to subsequent attempts at culture and infection. I studied on the morning of the 5th August the fluids of a larva which had died during the night. The blood obtained by snipping a proleg was thick and gray with bacteria, as were also the intestinal fluids, many in both blood and alimentary canal having the form and flagellate movement of Bacterium. Occasionally a string of four, attached end to end, would be seen in serpentine movement across the field. Well-stained and permanently mounted slides of their fluids show three bacterial forms: one large oval, undoubtedly *Bacterium termo;* one a smaller oval (the Micrococcus already described); and the third a somewhat peculiar oval form which might be understood as a single oval 1.5 μ long, with a pale center, or as a short double oval whose division was indicated, not by indentations of its margins, but by a thinning of its central part. The study of slides subsequently made under other circumstances enables me to say that this form last mentioned is really a developing Bacillus of a peculiar character which, matured, is short, broad, and quadrate, its central portion pale when stained, and the ends contrasting by a positively darker tint. Unable to identify this form with anything described, or to obtain through my botanical friends any specific determination of it, I shall refer to it in this paper, merely for convenience sake, under the provisional name of *Bacillus intrapallens.**

*I do not know that this is a distinct species, or intend so to imply. *Bacillus subtilis* sometimes presents the peculiar segregation of its contents here described, under what peculiarities of circumstance I do not know, but never, as far as I have observed or can learn, until the full size of the cell has been reached. In the above Bacillus, on the other hand, it was usually evident as soon as the young cell was large enough to show it.

Contagious Character of the Disease.

I made no effort to determine experimentally the question of the contagious character of this disease in *Datana ministra*, and can only report that it gradually invaded all the breeding cages of this and an allied species, *Datana angusi*, which we found during the season. Many of these were kept at a distance from those suffering from the disease, either as reserve or check lots, with the hope of protecting them from its operations; but as they were, at farthest, in adjacent rooms, and as we passed freely from one to the other, none of them can be said to have been *isolated*. The bacteria appearing in the walnut Datana *(D. angusi)* were not different from those infesting the other species, except that in our observations the spherical form was usually the characteristic one for this species. Still, both spherical and oval micrococci were noted in a multitude of instances.

Artificial Cultures.

Our first culture illustrating this disease was commenced September 6, 1883, with material obtained from an example of *Datana angusi* seriously affected, but not yet dead. The slide made from the fluids of this larva is not by any means pure. It shows in nearly equal quantities the spherical and oval micrococci described in the preceding section, the oval form mostly in doubles, each pair varying from 2.5 μ to 3 μ in length, and being .75 μ in transverse diameter. The spherules were mostly in doubles (the pairs somewhat under 2 μ in length) and in chains of four or more, the elements of which were sometimes quadrate. Many of both ovals and spheres were aggregated in large, dense patches. Very rarely, also, occurred a larger form, not measured, apparently a Bacterium.

Sterilized and neutralized infusion of beef was infected with fluids from this larva, by the methods and with all the precautions already described. This infusion speedily became milky, and slides made a few days after the culture was begun show clearly a reproduction of the spherical Micrococcus of the original fluid, but of no other form. In size, general appearance, and reaction to staining fluids, this differed in no par-

ticular from the original. Singles occurred occasionally, but most of the specimens were in doubles, no chains being noticed.

Additional slides, mounted October 2, show likewise the same spherical Micrococcus without admixture, or change in size or mode of aggregation; and still another series mounted from the same tubes, April 9, 1884, represent a still pure culture of what was probably this same Micrococcus. The specimens differ only by the somewhat smaller size, rarely surpassing .8 μ, — a difference probably to be accounted for by an exhaustion of the nutritive fluids, certain to have occurred during the seven months which had elapsed since the culture was begun. It should be said, also, that the slides of this last stage are less distinctly stained than the preceding, the micrococci very probably being dead.

After a careful re-examination of these materials I do not doubt that this was a successful culture of the spherical Micrococcus, preserved through the winter, practically unaltered, in a test tube plugged with cotton. It should be added that the check tube remained throughout unchanged.

An interesting culture was begun September 8, the material being obtained from a larva of *Datana ministra* dead several hours. The slides representing this larva are impure, the fluids from the alimentary canal containing not only spherical micrococci, but also a few ovals, and great numbers of bacilli. The spherical micrococci range in diameter from 1 μ to 1.25 μ, and are occasionally indistinctly quadrate, especially when occurring in chaplets (as they frequently do). A few doubles measure 3 μ. The bacilli are all slender, varying greatly in length (from 3 μ to 5 μ), but all .7 μ in transverse diameter.

The beef broth infected with this material on the 8th September was observed on the 15th to have become slightly milky, and, examined, was found to contain micrococci in couples and chaplets, chiefly arranged in the latter form. The slides made from this culture contain no bacilli, but only spherical or subquadrate micrococci in doubles and strings. These average a scant micro in diameter, some, however, reaching 1.25 μ. October 2 these fluids were found to contain only the same Micrococcus, not distinguishable in any way from

those on the slide already described ; and even on April 24 of the following year, the test tube, which had been preserved over winter, yielded only the same Micrococcus, as shown by well-stained and mounted slides prepared at that time. Magnified 1400 diameters and carefully measured, the single spherules vary from 1 μ to 1.25 μ in diameter.

From the foregoing I infer a verification of the experiment just reported, by a second successful culture of the spherical Micrococcus of the Datana larva and its preservation, uncontaminated, until the following year.

The only gelatine film cultures made with this material were begun September 8. Six films of solid beef gelatine, touched with a needle point dipped into the fluids of a larva of *Datana ministra* and inverted over a deep cell containing a droplet of distilled water to prevent drying out, exhibited September 10 a rapid growth of the infection,—each, originally a mere point, being now about the diameter of a pin head, and some having penetrated upwards the thickness of the film. The growth of this mass was in the form of thick finger-like processes, extending upwards through the gelatine film,—the marginal increase however being uniform and continuous. When warmed, these gelatine-film bacteria took on the flagellate motion of Bacillus, and the stained slides made from them strongly indicate that they are young individuals of *Bacillus intrapallens.*

Infection Experiments.

A few experiments with cultivated material were made upon other Datana larvæ obtained from time to time out of doors, these being divided into experimental and check lots, and the food of the former treated with infusions containing the cultivated bacteria. These were among our first experiments, and the control cages were evidently imperfectly isolated. As a consequence, the experiments were brought to naught by the appearance of *flacherie* in all the cages with which we had to do. In each instance, however, the mortality was more immediate, and at first much greater, among the lots treated with the bacterial cultures than among those not purposely infected ; but the results arrived at are not insisted on, and no detailed account of these experiments is deemed advisable.

THE WALNUT CATERPILLAR.

(*Datana angusi*, G. & R.)

I have to report under this species a series of observations, cultures, and experiments, the longest which I attempted. Although these failed, in part, of their original purpose, they brought out incidental and unintended results of considerable interest, and seem to me worthy of somewhat detailed description.

On the 14th of August, 1883, a lot of the larvæ of *Datana angusi* were collected from a black walnut tree (*Juglans nigra*) in the university grounds at Normal, and brought to the office for experiment. Seven of these were placed in a breeding cage in the further end of the Laboratory, somewhat removed from all the other experimental lots. On the 30th of August one of these was found dead in the cage, having certainly perished since the preceding day. The body of this individual was very limp and flaccid and considerably shrunken, and no food occurred in the alimentary canal. Mounted slides of the blood show vast numbers of the short, broad Bacillus, with rounded or subtruncate ends and pale central area, which I have distinguished as *Bacillus intrapallens*. The blood was, in fact, a nearly or quite pure culture of this organism, only some smaller and apparently undeveloped forms being possibly micrococci, but more probably the above Bacillus in its earlier stages. These bacilli measured upon an average 1.25 μ by 2.5 μ, and occurred singly and in doubles, the doubles with truncate opposed ends and broadly rounded free extremities. Besides the above, the intestinal contents presented spherical micrococci, usually single, but occasionally in process of division. .8 μ to 1 μ in diameter. I strongly suspect that these apparent micrococci also were the above *Bacillus intrapallens*, undeveloped.

The next morning a second larva of this lot was found dead, having apparently succumbed several hours previously. The intestinal fluids contained a great variety of bacteria, including Bacterium, and multitudes of minute spherical micrococci; but no slides or precise descriptions were prepared.

On September 2 another larva died which had been ailing for two or three days. But very few bacteria were found in the blood, while the intestinal fluids were full of double ovals.

not flagellate. Mounted slides show numerous spherical or slightly quadrate micrococci, with many single and double ovals. The spherical form is .75 μ to 1 μ in diameter, some of the single ovals attaining a length of 1.5 μ. The usual length of the latter is, however, about 1.25 μ.

Another larva of this lot died during the night of the 3d September, and was examined on the following morning. Its intestinal contents were brown and nearly solid, requiring to be moistened for examination. They were noted as "full of single and double micrococci," but the slide prepared is so excessively poor that nothing satisfactory can be determined from it.

From this last larva a culture was made as follows: On September 1 freshly prepared strong beef broth was filtered, while hot, through sterilized filter paper into a four-ounce flask which had just been heated for an hour in an oven at 275°-300° Fahrenheit. This was stopped at once with a three-inch plug of raw cotton, freshly sterilized by several hours' heating as above, and was boiled with the plug inserted. This flask was left undisturbed until the 4th September, when it remained perfectly clear. It was then boiled five minutes without removing the plug and left to cool. A particle of the alimentary contents of the above larva, about as large as the head of a pin, was now taken up on the point of a recently heated needle. The plug of the flask was removed, the infection material introduced, and the flask plugged again with fresh sterilized cotton still hot from the oven. A check flask was set aside at the same time.

On the 5th September the fluid was evidently turbid throughout, but especially so at the edges, and a slight film was apparent upon the surface. The plug was loosened, and a droplet of the fluid was obtained upon a freshly heated glass rod. The mounted slide of this material was, unfortunately, worthless, but, from notes made at the time, it appears that the bacteria occurring were rather large "double ovals," nearly all motionless, but with an occasional flagellate individual. Compared with the original infection material, there was no question of the identity of the two.

On the 6th September these fluids were milky, and a film had formed on the glass at the edges, where the fluid had a

somewhat ropy appearance when shaken. The check flask was perfectly clear. On September 8 the infected infusion was covered with a thick white surface-scum and the whole mass of the fluid was strongly turbid. A droplet of the liquid contents was now drawn out for examination, with a freshly-made capillary tube pushed down through the plug. The thin film upon the slide was milky with bacteria, which presented, under the microscope, an appearance of double ovals with occasional small clusters or patches of the same object, and occasional strings of three. No other form was seen among myriads passed under the eye, and no flagellate motion was detected; this was, consequently, an unmistakably pure culture of this single organism. Admirable slides of this material, prepared at this time, further illustrate the purity of the culture, and show that many, perhaps all, of the so-called "double ovals" of my notes were immature *Bacillus intrapallens*, in most of which the pale center was but just beginning to show. On the 13th of September a number of additional slides were made from this same flask, the contents of which were now extremely turbid, the lower half thick with a whitish sediment, and the surface and the flask about the edges covered with a scum. These slides contain only the above Bacillus, somewhat increased in size, and showing the characteristic pale center more distinctly. Considering the frequency with which this form occurred in the dead Datana larvæ of this lot, I have no doubt that this was a successful culture of this particular Bacillus.

On the 17th September these fluids were selected for an experiment intended to test the possibility of preserving throughout the winter the bacteria contained in them, and a number of films were spread upon glass slides previously sterilized by heating, dried immediately with moderate warmth, and laid away for preservation. At the same time small glass tubing was taken, heated thoroughly in the flame of a lamp, and divided by melting, while still almost red hot, into short tubes closed at both ends. As soon as cooled, these partially exhausted tubes were first filled with the bacterial culture by breaking off beneath the fluid, with sterilized forceps, the tip of the tube, which then filled by atmospheric pressure; and were then immediately re-sealed by heat and laid away in

cotton for the winter. Several of them were opened in the spring and summer of 1884, at various dates, and found always to contain only a pure culture of the original Bacillus, the results of the first examination, made April 4, not differing in this respect in any particular from the last, made July 30. These bacteria stained much less freely than those in the fresh culture, — a fact probably to be accounted for by their dormant condition. Occasionally a spherical or subquadrate form, 1 μ to 1.25 μ, is distinguishable in the field by a deeper stain, — possibly a spore of the preceding.

Next came a culture in beef broth made by the usual method from the contents of these tubes on the 23d of June, 1884. Two days later this was slightly turbid, decidedly so on the 26th, and on the 27th, when slides were made and the material was used for an infection experiment, they were almost milky. The contained bacteria now consisted of two forms: that frequently mentioned above as *Bacillus intrapallens*, and a spherical form indistinguishable from rather large micrococci. The bacilli occurred singly, doubly, and in strings, were 1 μ by 3 μ in typical specimens, but varied considerably, especially in transverse diameter, reaching sometimes a width of 1.5 μ. The spherules, on the other hand, averaged about 1 μ in transverse dimension. These occurred in various arrangement, but especially in long chaplets. Many of them presented a slightly quadrate outline and in a great number of instances strings of these were continuous with shorter filaments of the bacilli. Occasionally I satisfied myself that two or three of these spherical forms were contained within the Bacillus cells; that they were probably, indeed, to be considered as spores of the cells or, as seems to me more consistent with the facts, as an alternate form of the Bacillus. They seemed not to be developed by the transformation of the contents of an entire Bacillus filament, but rather to be separated off from the end of such a filament by a transformation of the protoplasm in the thickened ends of the cells.

Numerous other cultures were made from this same material. One commenced July 30 was found, August 1, to be decidedly turbid, and on the 2d to have formed a thin transparent pellicle over the whole surface. On the 3d this tube

was opened. The fluid was covered with a rather thick film made up wholly of the above *Bacillus intrapallens*, as determined at the time and as shown by beautifully stained and well-mounted slides which I have studied recently Many of these were in long filaments, but none showed any sign whatever of flagellate motion. This culture, like the preceding, was subsequently used for an infection experiment.

Similar cultures from the same material were made April 21 and 24, three tubes being inoculated on the latter date. From all these was obtained the same bacillar form, having occasionally associated with it the sphericals already mentioned, and in a single instance containing also a small Micrococcus about .5 μ in diameter.

The general results of these cultures unquestionably establish the possibility of preserving through several months the bacterial form here dealt with, and afterwards cultivating it successfully in beef broth.

I have next to describe the infection experiments with this Bacillus, showing the possibility of instituting disease in healthy larvæ by means of it, and of procuring its multiplication within their bodies for some days subsequent to the infection.

THE ZEBRA CATERPILLAR.

(*Mamestra picta*, Harris.)

A small colony of zebra caterpillars found on cabbage near Bloomington was brought to the Laboratory June 1, for infection experiments with one of the above cultures,—that begun June 23 and found to contain the *Bacillus intrapallens* and the spherical Micrococcus, as detailed above. A quantity of this fluid was poured into a dish June 27, and a single cabbage leaf was soaked in it for an hour and then fed to the larvæ. These ate freely of it, and were thereafter fed daily with fresh cabbage and carefully attended, this first infection, being the only one purposely made. A check lot of the same brood was placed in a separate cage, but unfortunately removed only a few yards from that infected.

On the next day a single larva of the first lot was found almost dead, and, being isolated, died during the night.

Examined June 29, at nine o'clock a. m., the fluid obtained by snipping off a proleg was found swarming with large bacilli, motionless at first, but beginning to move actively in all directions when exposed to the air under the cover. These bacilli measured from 2.5 μ to 5 μ in length, one apparently undivided reaching a length of 8 μ, with a transverse diameter of 1.5 μ. These presented no appearance of spores; the ends were broadly rounded, the sides parallel. Small numbers of micrococci occurred in the same slides, about .7 μ in diameter, strictly spherical, in singles and doubles. An examination of carefully stained slides leaves little room for question of the identity of these bacilli with some of those introduced with the food, but the interval was too short to make it certain that they had multiplied since ingestion. Their occurrence, however, in such vast numbers in the blood so soon after death, makes it very unlikely that they merely represented an escape of the intestinal fluids, especially as we shall soon see that the same bacilli occurred abundantly in the blood of larvæ not yet dead. The intestinal contents were full of the above Bacillus and the usual Micrococcus, 1 μ in diameter, in singles, doubles, and patches. The food contents were partially digested.

Besides the above bacteria, the blood was yellow with masses of cells with granular contents, many with a large nucleus each. These cells were apparently derived from the fatty bodies, which seemed to be in process of disorganization, but differed from the usual mulberry bodies which result from pupal histolysis, by the fact that there was no appearance of the division of the cell contents into mulberry granules.

Another larva observed this day, June 29, evidently torpid and apparently sick, seemed to have moulted imperfectly, fragments of the skin still clinging to the shrunken posterior segments. The body was flaccid, but not discolored. A proleg being snipped off, no flow of blood followed, but the fluid pressed out contained a moderate number of the above bacilli, no micrococci, but many well-defined mulberry cells and granules. Each of the cells contained from ten to fifteen or twenty of the latter. The alimentary contents contained micrococci with an occasional Bacillus, but none of the mulberry granules, both forms of bacteria being in this larva much

less abundant than was usually the case with individuals so seriously affected. The epithelial cells of the intestine contained granular masses, seemingly of the micrococci, and the fluid bathing them was thick with the same objects. Occasionally patches or clusters of the micrococci occurred in contact with the food. The stained and mounted slides of the blood show chiefly mulberry granules, spherical or somewhat angular in outline, 1.5 μ to 3 μ in diameter. A small number of spherical micrococci also occurred, many of them minute, ranging from .6 μ to .8 μ. These appear in all the usual forms of aggregation, including doubles, short chaplets, and patches of considerable size. Bacilli also occasionally occur, with parallel sides and rounded ends, from 1.25 μ to 1.5 μ in transverse diameter, and from 3 μ to 4 μ in length. A single *Bacillus intrapallens* was noticed in process of development, measuring 1.75 μ by 2 μ.

On the 30th June still another larva died, the grayish fluids of which contained immense numbers of the spherical micrococci, single and double, with vast quantities of the bacilli above described,—motionless at first, but soon, near the edges of the cover or in the vicinity of a bubble, commencing active flagellate movements. The body of the next larva to die, (July 1,) was flaccid, and contained little fluid. Immense numbers of spherical micrococci, 1 μ in diameter, occurred in the blood, mostly in doubles, together with many ovals about 1.5 μ long. Neither Bacterium nor Bacillus were detected in this specimen.

On the 2d, a caterpillar, evidently diseased, shrunken, and shortened, but with colors yet bright, was found lying upon the floor of the cage, able to right itself when turned over, but making no effort to escape. Blood from a foot of this larva contained a great number of unsegmented cells, similar to blood corspucles, but of variable size and shape, some with and some without nuclei. A few hours later, when the blood was examined again, besides these cells were found a considerable number of segmented bodies and mulberry cells, the latter evidently due to dissolution of the former. The next day this segmentation of the cells in question had gone still farther in this larva, and very many mulberry cells were distinguishable, together with others but partly segmented.

Now killing the larva, I found the fluids full of mulberry cells and granules, together, with a great number of spherical micrococci,—so determined by staining coagulated films.

On the evening of July 1 a number of larvæ in this cage were curiously affected, the prolegs, except the anal pair, being enlarged and swollen, with a slight reddish discoloration. These larvæ were evidently greatly annoyed by their condition, and dragged themselves clumsily about as if half paralyzed. One was seen to turn violently upon itself, and bite the swollen prolegs, as if in pain, so that the blood flowed from them freely. On the following morning one of these caterpillars was crawling about with the abdomen twisted and the prolegs turned almost upwards. Carefully snipping one of these swollen legs, I found in the blood an extraordinary number of lymphoid corpuscles, and a very considerable number of mulberry cells, but little, if any, larger than corpuscles of the blood, varying from circular to oval in optical section. Frequently a nucleus was visible in the midst of the mulberry granules, but no cell walls were distinguishable. The unstable character of the segmentation of these cells was unexpectedly demonstrated by the effect of a little carbolized water run under the cover. As a consequence, the segmentation entirely disappeared, the mulberry cells being all re-converted into simple nucleated corpuscles with granular contents. In fact, I happened to witness this retrogression of a mulberry cell, — a mass of distinct granules with a nucleus dimly seen among them, converted, with a curious internal commotion, into a common lymphoid corpuscle, of rather large size, with clearly distinguishable nucleus. In this condition the cells were indistinguishable from dead blood corpuscles. No bacteria were visible in these fluids.

On the 3d July one of these larvæ died. The body contained but little fluid, but this was loaded with cells, some unsegmented nucleated sphericals of various sizes, without trace of cell wall, staining deeply with aniline; and others well-developed mulberry cells, but so similar to the foregoing as to have been apparently derived from them. On the mounted slides of this material are also great numbers of separate mulberry granules and the usual spherical micrococci, the

latter averaging 1 μ in diameter, with an occasional Bacillus like those already several times mentioned. Micrococci and bacilli were, however, less abundant in these fluids than is commonly the case with larvæ destroyed by bacterial disease.

In a peculiar larva which died July 2, a small specimen that had scarcely grown since it was first placed in the cage, a few micrococci were found, and a considerable quantity of the mulberry granules, although this individual caterpillar must have been far from the pupal stage of development.

In another larva examined at the same time, likewise dwarfed, although larger than the preceding, the blood was gray with the usual Micrococcus, both free and in masses, and contained likewise great numbers of mulberry cells and granules. On the 12th July a larva died in whose blood no bacteria were detected, save a few of the usual bacilli. Its fluids contained, however, an immense number of mulberry cells and granules.

From the 12th to the 14th July eight more larvæ died in this lot with symptoms and microscopic characters like those already described,—the body usually somewhat shrunken and flaccid and the colors unchanged. The blood was occasionally gray with micrococci, but more commonly differed in appearance from that of healthy larvæ, only by the slightly yellowish or whitish tinge. The original Bacillus found in the earlier specimens occurred but once in these, and then in trifling quantity. The ordinary Micrococcus was more commonly present, sometimes, indeed, profusely abundant, but at other times in relatively trivial numbers. The unvarying and characteristic feature was the number of free cells in the blood, of variable form and size, some of them being altered blood corpuscles and others evidently derived from the fatty bodies. These occurred in all stages of segmentation, from a mere trace of commencing subdivision to a complete separation of the entire contents of the cell into more or less equal granules. The absence of an enclosing wall was unquestionably evident, granular masses being occasionally found from which a single one of the mulberry granules had broken away, leaving the remainder undisturbed. When the segmentation of these cells was incomplete or indefinite, they readily reverted to nucleated cells with gran-

ular protoplasm, if treated with alcohol or carbolized water. In many of the mulberry cells the nucleus persisted, surrounded and obscured by completely formed granules, but in others this seemed likewise to have participated in the metamorphosis of the body of the cell. The number of granules in a single cluster varied from three or five to fifteen or twenty in an optical section of the mass. The few remaining larvæ of this lot were now transferred to alcohol and glycerine for histological study.

In the meantime matters had taken a somewhat unfortunate course in the so-called check lot, these larvæ commencing to die mysteriously on the 30th of June. The first victims were two dwarfed specimens which had evidently moulted very imperfectly, being still covered with fragments of the old integument. An examination of the fluids of these specimens afforded no explanation of their death, as they contained neither bacteria in any appreciable number nor any cellular bodies. Another affected larvæ proved to have been parasitized.

Next two larvæ were found dead upon the morning of July 3, the fluids of which were grayish in hue. These contained no recognizable bacteria whatever, but were loaded with segmented mulberry cells.

On the 10th of July a larva died whose blood contained a moderate number of micrococci in doubles and chains, concerning which no further notes were made at the time and the slides illustrating which were lost.

A larva evidently diseased on the evening of this day was noticed the next morning with several spherical masses of excrement clinging to the vent, connected with each other by a delicate film. This film was dissected off, stained and mounted, and found to consist of an exceedingly delicate, structureless, but rather firm, membrane (doubtless the cuticle of the intestine) through which were dispersed great numbers of micrococci,—unquestionably a pure culture. These were mostly collected in patches, some compact and well defined, others more or less diffused. The compact clusters varied in outline from nearly circular to elongate oval. One of the latter was 35 μ long by 8 μ wide; others were respectively 18 μ by 20 μ, 16 μ by 16 μ, and 12 μ by 20 μ. The micrococci composing

them were 1 μ in average diameter, slightly oval to the eye, though not measurably so.

On the morning of the 12th two other larvæ were dead. The blood of one contained only immense numbers of mulberry granules with a moderate number of possible spherical micrococci,—not positively distinguishable in our slides, however, from the smallest mulberry granules. The blood of the other larva was in a similar condition, heavily loaded with mulberry cells and the results of their disintegration, but contained, likewise, a small number of various bacteria,—rarely a short, broad Bacillus, apparently identical with that first used in the experiment; more abundantly a small spherical Micrococcus, differing in appearance from the usual form; also a double oval Micrococcus, and an occasional patch of the true spherical so abundant in these experiments. These last were sometimes associated on the slides with patches of unsegmented cells, which evidently had their origin in the fatty bodies.

The third larva dead this day was soft, shrunken, and nearly dry. The scanty fluids were full of micrococci and thick with mulberry cells and granules. The effect of carbolized water upon the cells was, in this case, to cause separation into their constituent particles.

The results of all the above observations and experiments upon the zebra caterpillar may be summarized as follows: At least one of the bacillar forms occurring in the culture used in this infection was conveyed to the larvæ under experiment with fatal effect, and probably multiplied there successfully. This Bacillus almost wholly disaapeared, however, in the later stages of the experiment, and so is not certainly a true pathogenic form. Associated with this in the fluids of the larvæ treated were the usual spherical micrococci of this disease, clearly identical with those applied to the food, and certainly multiplying freely in the bodies of the larvæ. These presented, consequently, the characteristics of a pathogenic microbe. A curious change was observed in the phenomena of the disease in the experimental lot. Death seemed at first occasioned by the immediate action of the bacteria ingested or cultivated in the blood and alimentary fluids; but at a later period after the

infection, these bacterial forms became less abundant, and the blood was loaded with the products of histolysis, partly, in all probability, of the blood cells and partly of the fatty bodies. There seems to have been in general an inverse relation between the abundance of the bacteria and the abundance of these histolysis products, the former becoming less numerous with lapse of time and the latter more so. These facts have an interesting application to those observed in the silkworm, as detailed on previous pages, the condition of the later examples of the zebra caterpillar being, in fact, almost precisely similar, so far as microscopic appearances go, to that of silkworms supposed to be suffering from jaundice.

I have, consequently, to suggest a similar explanation of these phenomena; viz., that in the case of the latter larva the bacterial affection largely lost its power, but still retained sufficient energy to overthrow the physiological balance as the larvæ approached the age of pupation, death resulting from the premature histolysis of certain of the larval structures,—notably the fatty bodies.

The history of the check lot gives no evidence of serious bacterial infection, but rather of that modified form of it which produces premature pupal histolysis. Reviewing the entire series of slides and cultures, I have no doubt that these indicate the successful preservation through the winter and transference to the bodies of the zebra caterpillars of certain of the forms characteristic of *flacherie* in the walnut caterpillar, *Datana angusi.*

THE EUROPEAN CABBAGE WORM.

(*Pieris rapæ*, L.)

A second infection experiment was begun with the same fluids as the foregoing upon fifty cabbage worms, twenty-five of which were selected for treatment, and an equal number isolated as a check.

On the 6th August, four days after the infection, a larva was found dead upon the bottom of the cage. On puncturing the back a clear, greenish fluid exuded, which was swarming with a large and very active Bacillus, occurring usually in

doubles. Stained slides of this exhibit the same characteristics as those made directly from the culture used for the infection, but nothing else is evident.

On the same day another larva was found dead and blackened, clinging to the side of the cage, in quite different condition, however, from cabbage worms affected by their own peculiar disease. The body contained but little fluid, and that was of a paste-like consistence, full of the above bacilli, which the mounted slides show to be an absolutely pure culture.

Another larva, which died the following day, August 7, was found to present precisely the same microscopic characters, only large bacilli occurring in the slide. By the 10th ten of the specimens under experiment had either pupated or were evidently making preparations for that change. But two were apparently diseased. One of these last perished on the 12th, its body soft, pale, blackened posteriorly, but not deliquescent. The blood contained a multitude of minute spherical granules, some Bacillus-like structures, more slender than those previously occurring, and also floating cells of the fatty bodies containing mulberry granules, irregular in size, and sometimes showing also a central nucleus. With these were many large micrococci, 1 μ in diameter, circular, or sometimes slightly oval, commonly in singles or doubles, with rarely a chaplet of four. This larva soon became deliquescent, as if affected by the original *flacherie* of the cabbage-worm ; its condition, in fact, indicating a mingling of two diseases,—that conveyed by the infection to the larvæ, just described, and the one native to the species. It will be noted that one of the effects of the original infection seemed already to have waned, and that the development of the mulberry cells and granules characteristic of this condition had already occurred, — a phenomenon especially significant, since in the native disease of these cabbage caterpillars no similar condition of the fluids was ever seen. Another larva, dead this day, presented appearances so precisely similar to the preceding that no special description of it was made. The check lot, in the meantime, had progressed without injury. August 14 this experiment was interrupted, owing to a discovery of the fact that, through some oversight of the attendant, the full number of the larvæ placed

in the breeding cages could not be accounted for, several having, apparently, been allowed to escape as the food was changed. This partial experiment can, consequently, only be held to verify the conclusion drawn from the one just previously described, to the effect that the Bacillus used for infection may be at least temporarily propagated in healthy larvæ with destructive effect. It is proper to add that in the remnants of both the infected and check lots, the common *flacherie* of the cabbage worm afterwards broke out, showing that these insects had been exposed to this disease before they were brought to the office for the experiment.

Muscardine.

This disease, long well known in the silkworm, is not a bacterial affection, but is due to an invasion of the body of the insect by the filaments of a "thread fungus" (Hyphomycetes), whose spores germinate on the surface. These send thread-like processes through the skin which at first bud off from their free ends, within the body, short cells (sometimes called "conidia") with which the blood of the diseased insect speedily becomes loaded. These multiply by division, and finally result in a thread-mycelium which makes its appearance on the surface of the insect, and bears vast numbers of spores, white or green, with which the body becomes covered as with a fine dust. An affected larva is commonly flaccid and shrunken at death, but finally, as a consequence of the *post mortem* development of the fungus, becomes filled with threads and spores, and distended to its original size, drying without shrinkage into a hard and brittle mummy.

These later stages of the development of the fungus are greatly affected by the weather, a drouth preventing the conspicuous external appearance of the mycelium and the development of spores, and thus limiting the spread of the disease.

Every experienced collector finds occasional examples of this disease in the field in the form of stiff and mummified insects, often covered with a dense white or greenish bloom; but few observations of any wholesale destruction of a superabundant species by it have been recorded,—none for America

as far as I am aware. The following observations on the history of a tremendous outburst, in southern Illinois, of a species of caterpillar, one of the most destructive insects known, and of the means by which this irruption was apparently terminated, will consequently be of considerable interest.

In April and May, 1883, the extreme southern part of the state, from Cobden southward, was the scene of one of the periodical uprisings of the forest tent caterpillar (*Clisiocampa sylvatica*), which have doubtless occurred at intervals in that region from time immemorial. Vast numbers of forest trees in the southern counties of Illinois and in the adjacent parts of Missouri and Indiana were as completely defoliated as if mid-winter had suddenly burst upon them in May, and whole orchards of many acres of apple trees were left without a single green leaf. Oak, hickory, the black and sweet gum, and dog-wood were the trees especially selected for destruction in the forest, and the apple on the fruit farms,—the foliage of the peach being scarcely touched, even when the trees were covered with the caterpillars. Strawberry fields were likewise vigorously attacked,—young fields being occasionally nearly eaten up.

By the 18th May, when my visit there was made, the larvæ had nearly all attained their growth and were travelling restlessly about by myriads, in every direction, in search of suitable places for pupation,—a few having, in fact, already transformed along the tops of fences and under rubbish on the ground. As I walked along the road sides my attention was immediately caught by the great numbers of dead larvæ dried against the boards of the fences, usually in a vertical position, and the multitudes apparently in a diseased condition, traveling more or less feebly, or resting motionless with the head downward. These larvæ were usually flaccid and shrunken posteriorly, but not especially discolored.

It was, unfortunately, impossible for me to make any careful examination of the disease at this time, and no other opportunity offered during the season.

Revisiting this region on the 11th July, an assistant found that the moths had all emerged sometime previously, but that from one half to three fourths of the cocoons had never yielded

the imago. From a few of these, parasites had evidently escaped, but in most cases there was nothing in the external appearance of the cocoon to explain the failure of its development. Returning to this region June 3d of the following year, we learned from A. J. Ayers, Esq., of Villa Ridge. that a sufficient number of larvæ hatched that spring to do considerable damage, but that when they were a little over one half an inch long they died and dried upon the leaves, sometimes whole colonies being found dead together. Occasional examples of larvæ in this condition could even then be found on the apple-trees. A few apparently healthy examples were collected at this date and brought to the Laboratory at Normal. These were carefully fed and attended, with the expectation of obtaining the imago, but all died, without exception, with symptoms precisely resembling those of the year before, as they then came under my observation.

The first of these larvæ was seen to be sick on the 27th June, ejecting from the mouth and vent a fluid which contained great numbers of oval corpuscles, not unlike those characterizing *pébrine*, but varying appreciably in size and shape. Examples were found in process of sub division, or even, in occasional instances, short strings of three not wholly separated; and other examples occurred where a spherical lobe was borne upon the end of an oval cell, as if the latter were budding endwise. All these appearances were inconsistent with the hypothesis of the presence of *pébrine*, the characteristic "corpuscles" of which develop by internal segmentation of spherical masses (Sporozoa) and are never connected in doubles nor multiply by fission. Dissections of these larvæ afforded evidence that they were attacked by muscardine. In specimens which had lain some time it was not difficult to identify a scanty mycelium in the body, although, owing probably to the dry and warm weather at this season, there was no external development of the fungus either in the form of threads or spores. These larvæ continued to die until July 5, at which time the last perished.

The individual cells found in the blood varied from 2 μ to 3.5 μ, and in length from 3.5 μ to 5 μ. They differed also in shape, some being a rather broad symmetrical oval, and others

narrower towards one extremity. Nuclei about one half as long and wide as the cells containing them were visible in most. Neither cells nor nuclei stained readily with aniline.

The blood of many of the larvæ examined contained also considerable numbers of mulberry cells of rather large size, composed of granules averaging about 2 μ in diameter.

As no insects affected by muscardine had been handled by us at the time these caterpillars were received at the office, it is certain that they brought the infection with them; and as all perished, without exception, from this same disease, and this without the development of spores by which the contagion might have been conveyed from one to another, the presumption is very strong that the affection illustrated by these individuals was that which had swept away the greater part of the entire brood of the preceding year, and especially that which had caused the death of the young larvæ as reported by Mr. Ayres.

SUMMARY AND CONCLUSION.

The circumstances under which the studies above described have been made; the fact that they belong to a field of research so difficult that new comers are very properly viewed with a certain suspicion until they have clearly demonstrated their right to labor in it; and the further fact that my results have not always emerged from the cloud of experiment with perfectly clear and definite outline, have seemed to me to require in this paper a quantity of detail sometimes amounting, perhaps, to wearisome prolixity; and the following summary of the principal features and results of my research has been prepared in the hope that it may serve to make this mode of treatment less objectionable.

I have first attempted to characterize a common and highly destructive disease of the European cabbage worm *(Pieris rapæ)*, by whose ravages the injuries of these pests have received a very important check,—a disease especially marked by the whitish color of the living larvæ, amounting before death to an ashy or almost milky hue, and by a rapid *post mortem* blackening and decay. The distinguishing microscopic appearances are, first, a remarkable whiteness and opacity of the circulating fluids which are early loaded with immense numbers of very

minute spherical granules from .5 μ to .7 μ in diameter, staining with aniline fluids, although sometimes with difficulty, and less highly refractile than ordinary micrococci; second, a great degeneration of the mucous membrane of the chiliferous stomach producing before death a marked diminution in the thickness of the epithilial layer; and third, the appearance in the alimentary fluids, and usually also in the blood, of sphericals and ovals (especially the former), presenting every characteristic of unmistakable micrococci. Few if any of the blood granules are affected by ether, and they dissolve in hot caustic potash little, if at all, more readily than known micrococci, bacilli, and bacillar spores,* but they are not all of them certainly to be understood as of bacterial character. The fatty bodies are the next organs to suffer, after the alimentary canal, and speedily undergo an immense degeneration.

That this disease is contagious is shown by its unequal distribution in the neighborhoods affected by it; by its gradual though rapid progression from one part of the field to another; by its evident independence of locality, climate, and weather; by its apparent progress across the country from east to west; by the probable success of experiments made to convey it from infected regions to others at a distance, not previously invaded by it; and, finally, by its evident bacterial character.

In 1883 and 1884, numerous cultures were attempted in beef broth by the strictest methods of fluid culture in tubes and flasks, the accuracy of which was attested by the fact that the check tubes in every instance remained unchanged throughout. Not all the cultures were successful,—several careful infections from the blood especially being without result; in other cases, however, such infections from the blood of still living larvæ yielded the spherical micrococcus figured in the plate, identical in appearance with that observed in the fluids of the diseased larvæ, but larger in average size than the supposed

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*Contrary to the statement frequently made respecting the effects of alkalies upon bacteria, I have found that hot solutions of caustic potash rapidly attack both the cells and spores of *Bacillus subtilis* and the common micrococci of fermentation. Two or three times heating to a boiling point in a strong solution is sufficient in most cases to completely destroy these microbes.

blood form. Cultures from the alimentary fluids were never without result, although occasionally impure; but the commonest forms there were micrococci like the above, and the next commonest an oval micrococcus of nearly the same size and general appearance. Specimens of Bacillus and Bacterium were frequent in these alimentary cultures, but far less constant than the micrococci. No opportunity offered for experimental infection of healthy larvæ of this or other species with the cabbage worm microbes, either native or cultivated, and consequently it must be confessed that, strictly speaking, the proof is incomplete that this affection of the cabbage worm is a germ disease, although it certainly amounts to very strong probable evidence.

More complete and conclusive studies were made of a disease of the silkworm apparently identical with that known to the French as *jaunes*, and called jaundice by English and American writers. This disease, distinguished especially to the eye by the decided yellow color and restless activity of the larvæ, by the tender skin, easily broken, and by the free flow of thin yellow blood, is microscopically characterized by an abundance, in the blood, of the spherical or polygonal granules and clusters of the same, resulting from the peculiar degeneration of the larval tissues proper to pupation,—these being in this case derived chiefly from the fatty bodies and in part also from the blood corpuscles. This disease, therefore, seems to be essentially a premature pupal histolysis of the fatty bodies,—or, more properly, to be due to a retardation of the pupation of the larva which takes unequal effect on the different tissues, the fatty bodies breaking down before the muscles and membranes are ready for pupal transformation.

Spherical micrococci .75 μ to 1 μ in diameter occur in the walls of the alimentary canal as accompaniments of this disease, and are believed to be one, at least, of the exciting causes of it, although it seems not impossible that other retarding influences may produce a similar effect in overthrowing the normal physiological balance as pupation approaches.

That this supposed jaundice was contagious, was shown by the phenomena of its occurrence at Champaign, and that the bacteria accompanying it were capable of exciting disease in other larvæ was proven by first cultivating them repeatedly

in beef broth and then producing in cabbage worms (*Pieris rapæ*) a similar disease by moistening their food with the culture fluids containing the bacteria. While this disease, artificially induced, in some cases came so near that of the native cabbage worm as to suggest that the bacterial treatment served only to excite the natural disease of the larvæ, in other cases it was clearly different from the above and presented characters so clearly like those of the silk worm *jaundice* that there could be little doubt of an actual transference of the original disease, especially when the blood of the sick cabbage worms was found loaded with the mulberry cells and granules of pupal histolysis.

I have next reported at length on a breeding-cage disease attacking the YELLOW-NECKED APPLE CATERPILLAR (*Datana ministra*) and the WALNUT CATERPILLAR (*Datana angusi*), so similar to the well-know *flacherie* of the silkworm that I have not hesitated to call it by that name. Its principal symptoms are those indicating a gradual weakening of the larvæ, usually accompanied by brownish fluid discharges from the vent and a consequent shrinking and softening of the body. The alimentary canal contains always great numbers of microbes, commonly of considerable variety,—including bacilli, bacteria, and micrococci, the most abundant and characteristic being oval and spherical micrococci not distinguishable from those mentioned above. The method of the appearance and spread of the disease in our breeding room indicated a contagious character; and this conclusion was verified by culture of some of the bacterial forms encountered and their successful use as an experimental virus.

The cultures (in beef broth and on thin gelatine films) related to both micrococci and bacilli, and both were preserved over winter in plugged test tubes and in small sealed tubes, cultivated the following season, and applied to the food of another species of larva,—the ZEBRA CATERPILLAR (*Mamestra picta*). The first result of this treatment was the destruction of several of the larvæ, in from two to six days, with a disease marked by the appearance in their intestines of great numbers of bacilli (in the specimens first to succumb) and micrococci (later). The affection seemed then to change its character to one resembling jaundice of the silkworm, the characteristic

histolysis granules commencing to appear in the blood of slightly affected larvæ as early as the fourth day after infection. Caterpillars thus attacked did not commence to die until the sixth day, and most lived until the 15th. As in the case of the silkworm jaundice with which this is compared, the bacterial affection was less evident than in more rapid and pronounced cases of disease, but the usual intestinal micrococci were always present in varying numbers.

The last infection experiment I had to report, began August 2, 1884, with the same fluid, applied to the food of the European cabbage worm, was abandoned August 14 because the assistant in charge was unable to account for all the larvæ,—some having evidently been allowed to escape when the food was changed. As far as carried, it tended to confirm the indications of the preceding experiment, the blood of those dying up to the 7th August being full of a large active Bacillus only, similar to that used in the infection, and those perishing later containing chiefly large micrococci together with mulberry cells and granules. Later the common *flacherie* of the cabbage worm appeared in the remnants of both the infected and check lots.

Finally in a note on muscardine I have attributed largely to this affection the disappearance of a vast host of the forest tent caterpillar *(Clisiocampa sylvatica)* which devastated the forests and orchards of a part of southern Illinois in 1883, basing this conclusion upon the observed phenomena of the disease appearing among them as compared with those accompanying the death of larvæ of this species from the same localities, perishing in our breeding cages the following year of demonstrated muscardine.

There now remains to me only the pleasing duty of acknowledging my grateful obligations for aid in this work to my first assistant, Mr. W. H. Garman, to whose faithful care and unimpeachable accuracy of manipulation the larger part of the bacterial cultures were due; to Prof. T. J. Burrill, who has had the kindness to examine many of my slides, giving me the benefit of his extensive acquaintance with the bacteria; and to Dr. H. J. Detmers, now of the State University of Ohio, to whom I owe, among many other favors of this character, the excellent photographs of micrococci reproduced in the plate.

ARTICLE V.—*List of the Described Species of Fresh Water Crustacea from America, North of Mexico.* By LUCIEN M. UNDERWOOD, PH.D.

INTRODUCTORY.

The economic relations of the fresh water Crustacea are rapidly calling them into general notice, since their importance as the natural food supply of many of our most valuable fishes

ERRATA.

On page 333 after *Tachidius* read Lilljeb.

On page 338, under *Daphnella brachyura* insert *Hab.*—Massachusetts *(Birge)*, Minnesota *(Herrick)*.

On page 340, for *Scapaoleberis* read *Scapholeberis*.

Brady, etc., it has not been thought desirable to repeat this synonymy, but merely to refer to the author giving it in full. For this reason *all* the European papers are not repeated for all the species they describe. In the American literature, however, it has seemed desirable to give every reference to each species, even at the risk of too great repetition.

The study of our fresh water Crustacea, with that of their marine congeners, commenced with Thomas Say, and has since attracted the attention of over thirty different writers, nearly all of whom have added one or more new species to our lists. Certain groups, like the *Phyllopoda* and *Astacidæ*, have been carefully monographed, and furnish a literature of great value; in others sufficient work has been accomplished to furnish a broad, if not a substantial, basis for further study; while in

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INTRODUCTORY.

The economic relations of the fresh water Crustacea are rapidly calling them into general notice, since their importance as the natural food supply of many of our most valuable fishes is established beyond question. It has seemed desirable that our scattered literature on this subject should be indexed and made available to students. The following preliminary list is not intended as a complete arrangement of genera and species. A thorough revision of many of these groups must precede any permanent arrangement, and this is not possible at present. It is, therefore, merely an index to the described species, with such references to American and foreign literature as will place the student in a position to make use at once of all that pertains to each species. In case a full synonymy is given in standard works, like those of Leydig, Claus, P. E. Müller, Brady, etc., it has not been thought desirable to repeat this synonymy, but merely to refer to the author giving it in full. For this reason *all* the European papers are not repeated for all the species they describe. In the American literature, however, it has seemed desirable to give every reference to each species, even at the risk of too great repetition.

The study of our fresh water Crustacea, with that of their marine congeners, commenced with Thomas Say, and has since attracted the attention of over thirty different writers, nearly all of whom have added one or more new species to our lists. Certain groups, like the *Phyllopoda* and *Astacidæ*, have been carefully monographed, and furnish a literature of great value; in others sufficient work has been accomplished to furnish a broad, if not a substantial, basis for further study; while in

several others the ground has scarcely been broken, save by the brief and miscellaneous descriptions of new species. As in all such miscellaneous work there has been much looseness of definition and probably partial or complete re-description, many of the species as given in the following list will ultimately be reduced to synonyms or otherwise disappear from sight. While we deplore this looseness we cannot wholly ignore work because it has been poorly performed, as some of our recent carcinologists have been prone to do.

The species of fresh water Crustacea, as given herein, comprise 313 names, distributed in 88 genera and 29 families, as follows:

	Families.	Genera.	Species.
COPEPODA	8	14	66
OSTRACODA	1	4	15
CLADOCERA	8	29	82
PHYLLOPODA	3	13	34
AMPHIPODA	3	4	16
ISOPODA	2	18	41
DECAPODA	4	6	59
	29	88	313

As to the relative abundance in the different sections of the country, too little is now known of the range of individual species to form any satisfactory conclusions. The following geographic table will, therefore, show the comparative amount of attention each group has received in different sections rather than an exact representation of geographic distribution:

TABLE OF DISTRIBUTION OF SPECIES AS KNOWN AT THE PRESENT TIME.

	Copepoda.	Ostracoda.	Cladocera.	Phyllopoda.	Amphipoda.	Isopoda.	Decapoda.	Totals.
Alabama	7	......	13	......	......	......	12	32
Arkansas	......	......	......	......	......	1	......	1
California	1	......	......	1	......	9	2	13
Colorado	1	3	2	4	3	......	......	13
Connecticut	1	......	......	2	3	3	......	9
Dakota	......	......	......	1	......	......	2	3
District of Columbia	......	......	......	......	......	......	1	1
Florida	......	1	......	1	1	......	5	8
Georgia	......	1	......	......	1	1	13	16
Idaho	......	......	......	......	......	......	1	1
Illinois	6	......	2	2	5	6	9	30
Indiana	1	......	......	1	3	4	11	20
Iowa	......	......	......	1	......	......	6	7
Kansas	......	......	......	11	......	......	7	18
Kentucky	4	......	3	1	1	1	7	17
Louisiana	3	......	......	......	......	......	5	8
Maine	1	......	......	......	2	......	1	4
Maryland	......	......	......	......	......	......	4	4
Massachusetts	11	1	24	4	1	6	1	48
Michigan	4	......	......	......	3	2	4	13
Minnesota	24	5	50	1	......	......	2	82
Mississippi	......	......	3	......	1	......	9	13
Missouri	......	......	......	......	......	1	7	8
Montana	......	......	......	2	......	......	1	3
Nebraska	......	......	......	......	......	......	1	1
New Hampshire	......	......	......	1	......	......	......	1
New Jersey	......	1	......	1	......	2	4	8
New Mexico	......	......	......	1	......	......	......	1
New York	4	1	1	4	1	6	6	23
North Carolina	......	......	......	......	......	......	4	4
Ohio	1	......	......	3	......	......	4	8
Oregon	......	......	......	......	......	......	2	2
Pennsylvania	......	4	2	3	1	4	2	16
Rhode Island	......	......	......	2	......	......	......	2
South Carolina	......	......	......	......	......	1	10	11
Tennessee	......	......	......	......	1	1	12	14
Texas	......	......	......	5	......	......	4	9
Utah	......	......	......	3	......	......	1	4
Vermont	......	......	......	......	......	......	1	1
Virginia	......	......	......	......	......	1	4	5
Washington	1	......	......	......	......	2	4	7
West Virginia	......	......	......	......	......	......	2	2
Wisconsin	1	......	24	1	2	......	6	34
Wyoming	......	......	......	1	......	......	3	4
Lake Superior	2	......	5	......	4	1	5	17
Lake Michigan	4	......	8	......	2	......	1	15
Lake Huron	......	......	......	......	1	1	......	2
Lake Erie	1	......	......	......	......	......	1	2
Lake Ontario	1	......	......	......	......	......	......	1
British America	3	......	......	1	......	7	6	17
Arctic America	......	......	......	3	......	1	......	4

In the above numbers Minnesota takes the lead with 82 species, owing to the extended study of the microscopic forms by Prof. C. L. Herrick. Massachusetts with 48 and Wisconsin with 34 owe much to the study of the Cladocera by Prof. E. A. Birge. Illinois with 30, to which might properly be added most of the 15 of Lake Michigan, shows the careful research of Prof. S. A. Forbes. Other states owe their relatively high rank to the elaborate monograph of the Astacidæ, by Dr. Faxon, that has recently appeared. The contrast between the States above mentioned and others shows the nature of the work for future investigators. When we consider that *twenty-seven* of the above States and territories do not exceed *ten* species (seventeen not exceeding five), and add Delaware, Nevada, Arizona, and Indian Territory, from which no species have been reported, we can begin to realize how meagrely the group has been studied. There ought to be a response by some one, or by many, from all these neglected regions.

Of the seven orders the *Copepoda*,* *Ostracoda* and *Cladocera*, including all the microscopic forms, have been studied only in the eastern half of the United States, if we except six species reported from Colorado by Chambers. In sharp contrast with this, 20 of the 34 *Phyllopoda* are known only west of the Mississippi River. Of the 17 *Amphipoda* four extend to Colorado, five to the Southern States, while the remainder seem confined to northern waters. The *Isopoda* and *Decapoda* are more uniformly distributed, and with the *Phyllopoda* extend to the Pacific coast.

The largest genera are *Cambarus*, with 50 species, *Cyclops* with 21 species, *Daphnia* with 15 species, *Porcellio* with 15 species, *Cypris* with 11 species, all the rest falling below 10. Forty-one of the 88 genera are represented by a single species.

In the preparation of this list the compiler has been greatly aided by kind-hearted zoölogists who have furnished copies of their papers, cited references, corrected synomymies, and otherwise contributed to the completeness of the list. Their generosity entitles them to public thanks by the compiler and by all who may use this list when published. Their names

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*This remark does not properly apply to the parasitic forms, as some species have been reported from the Pacific coast.

need not be mentioned here, for they comprise the entire number of living American writers, whose names appear in the following pages.

SYRACUSE UNIVERSITY, *April 1, 1886.*

I. List of the Species.

ORDER COPEPODA.

FAMILY CALANIDÆ.

I. Diaptomus Westw.

1. D. armatus Herrick. 10th Rep. Geol. Minn. 233 (1882); Final Report, 139 (1884).
Hab.—Minnesota (*Herrick*).

2. D. kentuckyensis Chambers. Jour. Cincinnati Soc. Nat. Hist. iv, 48 (1881).
Hab.—Kentucky (*Chambers*).

3. D. leptopus Forbes. Amer. Nat. xvi., 646 (1882).
D. longicornis, var. *leptopus* Herrick. Final Report, 140, 186 (1884).
Hab.—Massachusetts and Illinois (*Forbes*).

4. D. longicornis Herrick. 7th Rep. Geol. Minn. 90 (1879); Final Report, 140, 141 (1884).

D. castor Herrick. 10th Rep. Geol. Minn. 221 (1882); Amer. Nat. xiii, 624 (1879).
Hab.—Minnesota (*Herrick*).

5. D. minnetonka Herrick. Final Report, 138 (1884).
Hab.—Minnesota (*Herrick*).

6. D. pallidus Herrick. 7th Rep. Geol. Minn. 91 (1879); Amer. Nat. xiii, 383 (1879); Final Report, 142 (1884).
Hab.—Minnesota (*Herrick*).

7. D. SANGUINEUS Forbes. Bull. Ill. Lab. Nat. Hist., No. 1, 15 (1876); Amer. Nat. xvi, 647 (1882).—*Gissler*. Amer. Nat. xv, 689 (1881).—*Herrick*. Amer. Nat. xvii, 382 (1883); Final Report, 138 (1884).

Hab.—Illinois (*Forbes*), New York (*Gissler*), Alabama and Minnesota (*Herrick*).

8. D. SICILIS Forbes. Amer. Nat. xvi, 645 (1882).

D. pallidus, var. *sicilis* Herrick. Final Report, 142 (1884).

Hab.—Lake Michigan (*Forbes*), Minnesota (*Herrick*).

9. D. STAGNALIS Forbes. Amer. Nat. xvi, 645 (1882).—*Herrick*. Final Report, 139 (1884).

D. giganteus Herrick. 10th Rep. Geol. Minn. 222 (1882).

Hab.—Illinois (*Forbes*), Minnesota (*Herrick*).

II. EPISCHURA FORBES.

1. E. FLUVIATILIS Herrick. Amer. Nat. xvii, 384 (1883); Final Report, 133 (1884).

Hab.—Alabama (*Herrick*).

2. E. LACUSTRIS Forbes. Amer. Nat. xvi, 648 (1882).—*Herrick*. Final Report, 131 (1884).

?*Scopiphora vagans* Pickering MS. in DeKay. Nat. Hist. N. Y. vi, 62 (1844).

Hab.—Lake Michigan (*Forbes*), L. Ontario (*Pickering*).

III. LIMNOCALANUS SARS.

1. L. MACRURUS Sars. Oversigt af de indenlandske Ferskvands Copepoder (1862).—*Forbes*. Amer. Nat. xvi, 648 (1882).—*Herrick*. Final Report, 134 (1884).

Hab.—Lake Michigan (*Forbes*).

IV. OSPHRANTICUM FORBES.

1. O. LABRONECTUM Forbes. Amer. Nat. xvi, 645 (1882).—*Herrick*. Final Report, 134 (1884).

Potamoichetor fucosus Herrick. 10th Rep. Geol. Minn. 224 (1882).

Hab.—Illinois (*Forbes*), Minnesota (*Herrick*).

FAMILY CYCLOPIDÆ.

I. CYCLOPS MÜLL.

1. C. AGILIS Koch. Deutschlands Crustaceen h. xxi, t., 11 (1838).—*Forbes.* Amer. Nat. xvi, 649 (1882).
Hab.—Illinois (*Forbes*).

2. C. ATER Herrick. 10th Rep. Geol. Minn. 228 (1882); Final Report, 145 (1884).
Hab.—Minnesota (*Herrick*).

3. C. BREVISPINOSUS Herrick. Final Report, 148 (1884).
Hab.—Minnesota (*Herrick*).

4. C. DIAPHANUS Fischer. Bulletin de la Soc. Imp. de Moscow, xxvi, 93 (1853).—*Herrick.* Final Report, 160 (1884).
Hab.—Minnesota (*Herrick*).

5. C. ELONGATUS Claus. Die freilebenden Copepoden, 97, t. xi, figs. 1, 2 (1863).—*Cragin.* Trans. Kansas Acad. Science (1883).—*Herrick.* Final Report, 144 (1884).
Hab.—Massachusetts (*Cragin*).

6. C. FIMBRIATUS Fischer. Bulletin de la Soc. Imp. de Moscow, xxvi, 94 (1853).—*Herrick.* Final Report, 162 (1884).
C. crassicornis Herrick. 10th Rep. Geol. Minn. 232 (1882).
Hab.—Minnesota (*Herrick*).

7. C. FLUVIATILIS Herrick. 10th Rep. Geol. Minn. 231 (1882); Final Report, 159 (1884).
C. magnoctavus Cragin. Trans. Kansas Acad. Science (1883).
Hab.—Massachusetts (*Cragin*), Minnesota (*Herrick*).

8. C. INSECTUS Forbes. Amer. Nat. xvi, 649 (1882). —*Herrick.* Final Report, 152 (1884).
Hab.—Illinois (*Forbes*), Minnesota (*Herrick*).

9. C. MODESTUS Herrick. Amer. Nat. xvii, 500 (1883); Final Report, 154 (1884).
Hab.—Alabama (*Herrick*).

10. C. NAVICULARIS Say. Jour. Phila. Acad. i, 441 (1817).—*DeKay.* Nat. Hist. N. Y. vi, 62 (1844).—*Herrick.* Final Report, 163 (1884).

Hab.—Southern States (*Say*).

11. C. NAVUS Herrick. 10th Rep. Geol. Minn. 229 (1882); Final Report, 152 (1884).

Hab.—Minnesota (*Herrick*).

12. C. OITHONOIDES Sars. Forhandlinger Videnskabs-Silskabeh, 1862, 241.—*Herrick.* Final Report, 150 (1884).

?*C. tenuissimus* Herrick. Amer. Nat. xvii, 64 (1883).

Hab.—Kentucky, Alabama, Minnesota (*Herrick*).

13. C. PARCUS Herrick. 10th Rep. Geol. Minn. 229 (1882); Final Report, 148 (1884).

Hab.—Minnesota (*Herrick*).

14. C. PECTINATUS Herrick. Amer. Nat. xvii, 499 (1883).

Hab.— Alabama (*Herrick*).

15. C. PHALERATUS Koch. Deutschlands Crustaceen h. xxi, t. 9 (1838).—*Herrick.* Final Report, 161 (1884).

C. adolescens Herrick. 10th Rep. Geol. Minn. 231 (1882).

C. perarmatus Cragin. Trans. Kansas Acad.Science (1883).

Hab.—Massachusetts (*Cragin*), Minnesota (*Herrick*).

16. C. PULCHELLUS Koch. Deutschlands Crustaceen, h. xxi, t. 2 (1838).—*Cragin.* Trans. Kansas Acad. Science (1883).

Hab.—Massachusetts (*Cragin*).

17. C. SERRULATUS Fischer. Bulletin de la Soc. Imp. des Nat. de Moscow, xxiv, 423 (1851).—*Herrick.* 10th Rep. Geol. Minn. 230 (1882); Final Report, 157, 163 (1884).

C. pectinifer Cragin. Trans. Kansas Acad. Science (1883).

?*C. setosus* Haldeman Jour. Phila. Acad. viii, 331.

Hab.—Massachusetts (*Cragin*), Minnesota (*Herrick*).

18. C. TENUICORNIS Claus. Archiv. für Naturgeschichte 1857, 31, Tab. iii, figs. 1–11.—*Herrick.* 10th Rep. Geol. Minn. 227 (1882); Final Report, 153 (1884).

C. signatus, var. *fasciacornis* Cragin. Trans. Kansas Acad. Science (1883).

Hab.—Massachusetts (*Cragin*), Alabama and Minnesota (*Herrick*).

19. C. THOMASI Forbes. Amer. Nat. xvi, 649 (1882).—*Cragin.* Trans. Kansas Acad. Science (1883).—*Herrick.* Final Report, 153 (1884).

Hab.—Massachusetts (*Cragin*), Lake Michigan (*Forbes*).

20. C. UNIANGULATUS Cragin. Trans. Kansas Acad. Science (1883).—*Herrick.* Final Report, 149 (1884).

Hab.—Massachusetts (*Cragin*).

21. C. VIRIDIS Fischer. Bull. de la Soc. Imp. des Nat. de Moscow, xxiv 412, t. ix, figs. 1–11 (1851).—*Cragin.* Trans. Kansas Acad. Science (1883).—*Herrick.* Final Report, 145 (1884).

C. ingens Herrick. 10th Rep. Geol. Minn. 228 (1882); Amer. Nat. xvii, 499 (1883).

Hab.—Massachusetts (*Cragin*), Alabama and Minnesota (*Herrick*).

FAMILY HARPACTIDÆ.

1. CANTHOCAMPTUS WESTW.

1. C. CAVERNARUM Packard. Zoölogy, 298 (figure only).

Hab.—Kentucky (*Packard*).

2. C. ILLINOISENSIS Forbes. Bull. Ill. St. Lab. Nat. Hist., No. 1, 14 (1876).—*Herrick.* Final Report, 170 (1884).

Hab.—Illinois (*Forbes*).

3. C. MINUTUS Baird. British Entomostraca, 204, tab. xxv, figs. 4–8, xxx, fig. 3 (1850).—*Herrick.* Final Report, 170 (1884).

C. minutus, var. *occidentalis* Herrick. 7th Rep. Geol. Minn. 95 (1879).

Hab.—Minnesota (*Herrick*).

4. C. MINNESOTENSIS Herrick. Final Report, 173 (1884).

Hab.—Minnesota (*Herrick*).

5. C. NORTHUMBRICUS Brady, var. AMERICANUS, Herrick. Final Report, 170 (1884).

Hab.—Minnesota (*Herrick*).

II. Tachidius.

1. T. fonticola Chambers. Jour. Cincinnati Soc. Nat. Hist. iv, 47 (1881).

Hab.—Kentucky (*Chambers*).

FAMILY ERGASILIDÆ.

I. Ergasilus Nordm.

1. E. centrarchidarum Wright. Proc. Canadian Inst. i. 243 (1882).

Hab.—Canada; on various *Centrarchidæ* (*Wright*).

2. E. funduli Kroyer. Naturhistorisk Tidsskrift, ii. 228, 238, pl. 11, fig. 1 (1863).

Hab.—Louisiana; parasitic on *Fundulus fimbratus* (*Kroyer*).

FAMILY CALIGIDÆ,

I. Lepeophtheirus Nordm.

1. L. salmonis Kroyer. Naturhistorisk Tidsskrift, ii. 137, pl. 17, fig. 1 (1863).—*Smith.* Rep. U.S. Fish Com. for 1882–83, 662.

Hab.—Eastern U.S.; parasitic on the salmon.

FAMILY ARGULIDÆ.

I. Argulus Müll.

1. A. alosæ Gould. Invert. Mass., 340 (1841).

Hab.—Massachusetts; parasitic on alewife (*Gould*).

2. A. catostomi Dana and Herrick. Amer. Jour. Science, 1st series, xxx, 388 (1836).—*Smith.* Rep. U.S. Fish Com. for 1872–73, 662.

Hab.—Connecticut; parasitic on *Catostomus sp.* (*Dana*).

3. A. FUNDULI Kroyer. Naturhistorisk Tidsskrift, ii, 20, pl. 2, fig. 1 (1863).—*Smith.* Rep. U. S. Fish Com. for 1872–73, 662.

Hab. -Louisiana; parasitic on *Fundulus limbatus* (*Kroyer*).

4. A. LEPIDOSTEI Kellicott. Bull. Buff. Soc. Nat. Sciences iii, 214 (1877); Amer. Jour. Micros. iii, 1 (1878); iv, 153, (1879).

Hab.—Niagara River (*Kellicott*).

5. A. PUGETENSIS Dana. Crustacea, 1351 (1852).

Hab.—Washington Territory (*Dana*).

6. A. STIZOSTETHII Kellicott. Amer. Jour. Micros. v, 53 (1880); N. A. Entomologist, i, 57 (1880).

Hab.—Niagara River (*Kellicott*).

FAMILY LERNÆOCERIDÆ.

I. LERNÆOCERA BLAINV.

1. L. CRUCIATA Le Sueur. Jour. Phil. Acad. iii, 286 (1824). *DeKay.* Nat. Hist. N. Y. vi, 59 (1844).—*Smith.* Rep. U. S. Fish Com. for 1872–73, 665.—*Kellicott.* Proc. Amer. Soc. Micros. i, 64 (1879).

Hab.— Lake Erie (*Le Sueur*), Michigan (*Kellicott*). On *Centrarchus æneus.*

2. L. CATOSTOMI Kroyer. Naturhistorisk Tidsskrift, ii, 321, pl. 18, fig. 4 (1863).—*Smith.* Rep. U. S. Fish Com. for 1872–73, 665.

Hab.—Mississippi River (*Kroyer*). On *Catostomus macrolepidotus.*

3. L. PECTORALIS Kellicott. Proc. Amer. Soc. Micros. iv, 77 (1882).

Hab.—Michigan (*Kellicott*).

4. L. POMOTIDIS Kroyer. Naturhistorisk Tidsskrift, ii, 323, pl. xv, fig. 5 (1863).

Hab.—Louisiana (*Kroyer*). On *Pomotis sp.*

5. L. TORTUA Kellicott. Proc. Amer. Soc. Micros. ii, 41 (1880).

Hab.—Tributaries of Lake Ontario, New York (*Kellicott*).

FAMILY LERNÆOPODIDÆ.

I. ACHTHERES NORDM.

1. A. AMBLYOPLITIS Kellicott. Proc. Amer. Soc. Micros. iv, 76 (1882).
Hab.—Michigan (*Kellicott*).

2. A. CARPENTERI Packard. 7th Rep. U. S. Geol. Survey (Hayden), 611 (1874).
Hab.—Colorado (*Packard*).

3. A. CORPULENTUS Kellicott, Proc. Amer. Soc. Micros. iv, 75 (1882).
Hab.—Michigan (*Kellicott*).

4. A. LACÆ Kroyer. Naturhistorisk Tiddskrift, ii. 274, pl. 17, fig. 6 (1863).—*Smith.* Rep. U.S. Fish Com. for 1872–73. 663.
Hab.—North America (*Kroyer*).

5. A. MICROPTERI Wright. Proc. Canadian Institute, i. 249 (1883).
Hab.—Canada (*Wright*).

6. A. PIMELODI Kroyer. Naturhistorisk Tidsskrift, ii, 272, pl. 17, fig. 5 (1863).—*Smith.* Rep. U. S. Fish Com. for 1872–73, 662.
Hab.—Ohio River (*Kroyer*). On *Pimelodus maculatus.*

II. CAULOXENUS COPE.

1. C. STYGIUS Cope. Proc. Phila. Acad. 1871, 297; Amer. Nat. vi, 411 (1872); Third and Fourth Rep. Geol. Indiana, 167 (1872).—*Packard.* Fifth Rep. Peabody Acad. Sci. 94 (1873). *Smith.* Rep. U. S. Fish Com. for 1872–73, 665.
Hab.—Indiana (*Cope*).

III. LERNÆOPODA KROYER.

1. L. CALIFORNIENSIS Dana. Crustacea, 1379 (1852).
Hab.—California (*Dana*). On salmon.

2. L. COREGONI Smith. Rep. U. S. Fish Com. for 1872–73, 664, 697.

Hab.—Lake Superior (*Smith*). On *Coregonus albus*.

3. L. EDWARDSII Olsson. Prodrom. fauna Copepodarum parasit. Scand., 36 (1868).—*Wright*. Proc. Canadian Inst. i, 246 (1883).

Hab.—Canada (*Wright*).

4. L. FONTINALIS Smith. Rep. U. S. Fish Com. for 1872–73, 663.

Hab.—Maine (*Smith*). On *Salmo fontinalis*.

5. L. SISCOWET Smith. Rep. U. S. Fish Com. for 1872–73, 664, 697.

Hab.—Lake Superior (*Smith*). On *Salmo siscowet*.

ORDER OSTRACODA.

FAMILY CYPRIDIDÆ.

I. CANDONA BAIRD.

1. C. ELONGATA Herrick. 7th Rep. Geol. Minn. 113, (1879).

Hab.—Minnesota (*Herrick*).

2, C. ORNATA Herrick. 7th Rep. Geol. Minn. 113 (1879).
Hab.—Minnesota (*Herrick*).

II. CYPRIS MÜLL.

1. C. AGILIS Haldeman. Proc. Phila. Acad. 1841, 53.—*DeKay*. Nat. Hist. N.Y. vi, 65 (1844).

Hab.—Pennsylvania (*Haldeman*).

2. C. ALTISSIMUS Chambers. Bull. U.S. Geol. Survey (Hayden) iii, 152 (1877).

Hab.—Colorado (*Chambers*).

3. C. DISCOLOR Haldeman. Proc. Phila. Acad. 1842, 166.
Hab.—Pennsylvania (*Haldeman*).

4. C. GRANDIS Chambers. Bull. U. S. Geol. Survey (Hayden) iii, 151 (1877).
Hab.—Colorado (*Chambers*).

5. C. HISPIDA DeKay. Nat. Hist. N. Y. vi, 64 (1844).
Hab.—New York and New Jersey (*DeKay*).

6. C. MONS Chambers. Bull. U. S. Geol. Survey (Hayden) iii, 153 (1877).
Hab.—Colorado (*Chambers*).

7. C. NEGLECTA Herrick. 7th Rep. Geol. Minn. 112 (1879).
Hab.—Minnesota (*Herrick*).

8. C. SCABRA Haldeman. Proc. Phila. Acad. 1842, 184.
Hab.—Massachusetts (*Haldeman*).

9. C. SIMPLEX Haldeman. Proc. Phila. Acad. 1841, 53.—*DeKay*. Nat. Hist. N. Y. vi, 65 (1844).
Hab.—Pennsylvania (*Haldeman*).

10. C. VIDUA Müller. Zoöl. Dan. Prod. No. 2384 (1776); Entomostraca 55, t. 4, figs. 7–9 (1785).—*Herrick*. 7th Rep. Geol. Minn. 112 (1879).
Hab.—Minnesota (*Herrick*).

11. C. VITREA Haldeman. Proc. Phila. Acad. 1842, 166.
Hab.—Pennsylvania (*Haldeman*).

III. NOTADROMUS LILLJEB.

1. N. MONACHUS Lilljeborg. De Crustaceis ex. ord. tribus, 95, t. viii, figs. 1–15 (1853).—*Herrick*. 10th Rep. Geol. Minn. 252 (1882).

Cypris monachus Müller. Entomostraca, 60, t. 5, figs. 6–8, (1785).
Hab.—Minnesota (*Herrick*).

IV. CYTHERINA LAM.

1. C. BIFASCIATA Say. Jour. Phila. Acad. i, 439 (1817). *DeKay*. Nat. Hist. N. Y. vi, 65 (1844).
Hab.—Georgia and Florida (*Say*).

ORDER CLADOCERA.

FAMILY SIDIDÆ.

I. SIDA STRAUSS.

1. S. CRYSTALLINA Strauss. Mem. du Museum, t. vi (1820). —*Birge.* Trans. Wis. Acad. iv, 78 (1877).—*Herrick.* 7th Rep. Geol. Minn. 99 (1879); 10th Rep. Geol. Minn. 235 (1882); Final Report, 20 (1884).

Daphnia crystallina Müller. Entomostraca, 96, t. 14, figs. 1–4 (1785).

Hab.—Massachusetts, Lake Michigan, and Wisconsin (*Birge*); Minnesota (*Herrick*).

II. PSEUDO-SIDA HERRICK.

1. P. BIDENTATA Herrick. Final Report, 20 (1884).

Hab.—Alabama (*Herrick*).

III. DAPHNELLA BAIRD.

1. D. BRACHYURA Baird. British Entomostraca, 109 (1850). —*Herrick.* 10th Rep. Geol. Minn. 236 (1850); Final Report, 21 (1884).

D. winchelli Herrick. 7th Rep. Geol. Minn. 122 (1879).

? *D. exspinosa* Birge. Trans. Wis. Acad. iv, 79 (1877).

Sida brachyura Lievin. Branchiepoden der Danziger Umgegend, 20, t. iv, figs. 3–9 (1848).

IV. LATONA STRAUSS.

1. L. SETIFERA Strauss. Mem. de Museum, v, (1820).—*Birge.* Chicago Med. Jour. and Ex. xvi, 585 (1881).—*Herrick.* Final Report, 22 (1884).

Daphnia setifera Müller. Entomostraca, 98, t. 14, figs. 5–7 (1785).

Hab.—Massachusetts and Lake Michigan (*Birge*).

FAMILY HOLOPEDIDÆ.

I. HOLOPEDIUM ZADD.

1. H. GIBBERUM Zaddach. Archiv. für Naturgeschichte, 1855, 159, t. viii, ix.—*Forbes.* Amer. Nat. xvi, 641 (1882).—*Herrick.* Final Report, 22 (1884).

Hab.—Lake Michigan (*Forbes*).

FAMILY DAPHNIDÆ.

I. MOINA BAIRD.

1. M. RECTIROSTRIS Baird. British Entomostraca, 101, t. xi, figs. 1, 2 (1850).—*Birge.* Trans. Wis. Acad. iv, 79 (1877). *Herrick.* 10th Rep. Geol. Minn. 237 (1882); Final Report, 34 (1884).

M. brachiata Baird l.c. 102, t. ix, figs. 1, 2.

Daphnia rectirostris Müller. Entomostraca, 92, t. 12, figs. 1, 2 (1785).

Hab.—Alabama and Minnesota (*Herrick*); Wisconsin (*Birge*).

II. CERIODAPHNIA DANA.

1. C. ALABAMENSIS Herrick. Amer. Nat. xvii, 503 (1883); Final Report, 38 (1884).

Hab.—Alabama (*Herrick*).

2. C. CONSORS Birge. Trans. Wis. Acad. iv, 81 (1877). —*Herrick.* Final Report, 40 (1884).

Hab.—Wisconsin (*Birge*).

3. C. CRISTATA Birge. Trans. Wis. Acad. iv, 82 (1877). *Herrick.* Final Report, 38 (1884).

? *Daphnia reticulata* Herrick. 7th Rep. Geol. Minn. 104 (1879).

Hab.—Massachusetts and Wisconsin (*Birge*); Minnesota (*Herrick*).

5. C. LATICAUDATA P. E. Müller. Dänmarks Cladocera, 130, t. i, fig. 19 (1868).—*Herrick.* Final Report, 39 (1884).

Hab.—Minnesota (*Herrick*).

6. C. PARVA Herrick. Amer. Nat. xvii, 504 (1883).
Hab.—Minnesota (*Herrick*).

7. C. SCITULA Herrick. Final Report, 40 (1884).
Hab.—Minnesota (*Herrick*).

III. SCAPAOLEBERIS SCHÖDL.

1. S. ANGULATA Herrick. Amer. Nat. xvii, 502 (1883); Final Report, 44 (1884).
Hab.—Mississippi and Alabama (*Herrick*).

2. S. ARMATA Herrick. 10th Rep. Geol. Minn. 243 (1882); Final Report, 43 (1884).
Hab.—Alabama and Minnesota (*Herrick*).

3. S. AURITA Birge in Herrick's Final Report, 175 (1884).
S. nasuta Birge. Trans. Wis. Acad. iv, 85 (1877).—*Herrick*. Final Report, 43 (1884).
Daphnia aurita Fischer. Bull. Naturforsch. Gesellsch. in Moscau, xxii (1849).
Hab.—Wisconsin (*Birge*).

4. S. MUCRONATA Schödler. Branchiopoden der Umgegend von Berlin, 23 (1858).—*Birge*. Trans. Wis. Acad. iv. 84 (1877).—*Herrick*. 10th Rep. Geol. Minn. 241 (1882); Final Report, 42 (1884).
Daphnia mucronata Müller. Entomostraca, 94, t. xiii, figs. 6, 7 (1785).—*Herrick*. 7th Rep. Geol. Minn. 104 (1879).
Hab.—Eastern United States.

IV. SIMOCEPHALUS SCHÖDL.

1. S. AMERICANUS Birge. Trans. Wis. Acad. iv, 82 (1877).—*Herrick*. Final Report, 47, 49 (1884).
Hab.—Mississippi and Minnesota (*Herrick*); Wisconsin (*Birge*).

2. S. DAPHNOIDES Herrick. Amer. Nat. xvii, 503 (1883); Final Report, 48 (1884).
Hab.—Alabama (*Herrick*).

3. S. ROSTRATUS Herrick. Final Report, 47 (1883).
Hab.—Mississippi (*Herrick*).

4. S. VETULUS Schödler. Branchiopoden der Umgegend von Berlin, 18 (1858).—*Birge.* Trans. Wis. Acad. iv, 82 (1877). —*Herrick.* 7th Rep. Geol. Minn. 103 (1879); Final Report, 46 (1884).

Daphne vetula, Müller. Zoöl. Dan. Prod. No. 2399 (1776).
Hab.—Wisconsin (*Birge*), Minnesota (*Herrick*).

V. DAPHNIA MÜLL.

1. D. ABRUPTA Haldeman. Proc. Phila. Acad. 1842, 184.
Hab.—Pennsylvania (*Haldeman*).

2. D. ANGULATA Say. Jour. Phila. Acad. i, 440 (1817). *DeKay.* Nat. Hist. N.Y. vi, 65 (1844).
Hab.—Southern States (*Say*).

3. D. BREVICAUDA Chambers. Bull. U. S. Geol. Survey (Hayden) iii, 154 (1877).

Hab.—Kentucky and Colorado (*Chambers*).

4. D. DUBIA Herrick. Amer. Nat. xvii, 501 (1883); Final Report, 61 (1884).
Hab.—Minnesota (*Herrick*).

5. D. GALEATA Sars. Om en Sommeren 1862, foretagen zoologisk Reise i Christianias og Trondhjems Stiftor, 21 (1863). *P. E. Müller.* Naturhistorisk Tidsskrift, v, 117, pl. i, fig. 6 (1868).—*Smith.* Rep. U.S. Fish Com. for 1872–73, 695.—*Herrick.* Final Report, 61 (1884).
Hab.—Minnesota (*Herrick*); Lake Superior (*Smith*).

6. D. HYALINA Leydig. Naturgeschichte der Daphniden, 151, t. i, figs. 8–10 (1860).—*Forbes.* Amer. Nat. xvi, 642 (1882). —*Herrick.* Final Report, 60 (1884).

D. longispina Herrick. Amer. Nat. xvii, 501 (1883).

D. pellucida P. E. Müller. Naturhistorisk Tidsskrift, v. 116, pl. 1, fig. 5 (1868).—*Smith.* Rep. U.S. Fish Com. 1872–73, 696.

Hab.—Kentucky and Minnesota (*Herrick*), Illinois and Lake Michigan (*Forbes*), Lake Superior (*Smith*).

7. D. KALBERGENSIS Schödler. Die Cladocera des frischen Haffs, 18 t. i, figs. 1-3 (1863).—*Herrick.* Final Report, 63 (1884).

Hab.—Minnesota (*Herrick*).

8. D. KERUSSES Cox. Amer. Monthly Micros. Jour. iv, 88 (1883).—*Kellicott.* Proc. Amer. Soc. Micros. vi, 129 (1884).

Hab.—Wisconsin (*Cox*), New York (*Kellicott*).

9. D. MAGNICEPS Herrick. Final Report, 64 (1884).

Hab.—Minnesota (*Herrick*).

10. D. MINNEHAHA Herrick. Final Report, 59 (1884).

Hab.—Minnesota (*Herrick*).

11. D. PULEX Claus. Mem. de Museum, vii, 158 (1820).—*Smith.* Rep. U.S. Fish Com. for 1872-73, 696.—*Birge.* Trans. Wis. Acad. iv, 87 (1877).—*Herrick.* 7th Rep. Geol. Minn. 101 (1879); 10th Rep. Geol. Minn. 238 (1882); Amer. Nat. xvii, 501 (1883); Final Report, 56 (1884).

Hab.—Massachusetts and Wisconsin (*Birge*), Alabama and Minnesota (*Herrick*), Lake Superior (*Smith*).

12. D. RETICULATA Haldeman. Proc. Phila. Acad. 1843, 196.

Hab.—Pennsylvania (*Haldeman*).

13. D. RETROCURVA Forbes. Amer. Nat. xvi, 642 (1882).

Hab.—Illinois (*Forbes*).

14. D. ROSEA Sars. Om de i Omegn. af Christania forekom. Cladocera, 268 (1862).—*Herrick.* Final Report, 59 (1884).

Hab.—Minnesota (*Herrick*).

15. D. ROTUNDATA Say. Jour. Phila. Acad. i, 440 (1817.)—*DeKay.* Nat. Hist. N. Y. vi, 65 (1844).

Hab.—Southern States (*Say*).

FAMILY BOSMINIDÆ.

1. BOSMINA BAIRD.

1. A. CORNUTA Baird. Trans. Berwick Nat. Club, ii, 149 (——).—*Birge.* Trans. Wis. Acad. iv, 91 (1887).—*Herrick.* 10th Rep. Geol. Minn. 244 (1882).

Monoculus cornutus Jurine. Hist. d. Monocles qui se trouvent aux environs de Geneve, 142, t. xiv, figs. 8–10 (1820).

Hab.—Massachusetts (*Birge*), Minnesota (*Herrick*).

2. B. LONGIROSTRIS Baird. Ann. and Mag. Nat. Hist. xvii, 412 (——); British Entomostraca, 105, t. xv, fig. 3 (1850).—*Birge.* Trans. Wis. Acad. iv, 91 (1876).—*Herrick.* 7th Rep. Geol. Minn. 109 (1878); 10th Rep. Geol. Minn. 244 (1882).

Lynceus longirostris Müller. Entomostraca, 76, t. x, figs. 7, 8 (1785).

Hab.—Massachusetts and Wisconsin (*Birge*), Minnesota (*Herrick*).

3. B. STRIATA Herrick. 10th Rep. Geol. Minn. 32 (1882); Final Report, 66 (1884).

Hab.—Minnesota (*Herrick*).

FAMILY LYNCODAPHNIDÆ.

I. MACROTHRIX BAIRD.

1. M. PAUPER Herrick. 10th Rep. Geol. Minn. 245 (1882); Final Report, 70 (1884).

Hab.—Minnesota (*Herrick*).

2. M. ROSEA Baird. Trans. Berwick Nat. Club, ii, 149 (——); British Entomostraca, 104 (1850).—*Birge.* Trans. Wis. Acad. iv, 90 (1877).—*Herrick.* Final Report, 69 (1884).

Hab.—Wisconsin (*Birge.*)

3. M. TENUICORNIS Kurz. Dodekas neuer Cladocera, 26, t. iii, fig. 1 (1874).—*Herrick.* 10th Rep. Geol. Minn. 245 (1882); Final Report, 70 (1884).

M. agilis Herrick. 7th Rep. Geol. Minn. 106 (1879).

Hab.—Minnesota (*Herrick*).

II. LATHONURA LILLJEB.

1. L. RECTIROSTRIS Lilljeborg. De Crustaceis ex ordinis tribus, 57, t. iv, figs. 8–11, t. v, fig. 2, t. xxiii, figs. 12–13 (1853).—*Birge.* Trans. Wis. Acad. iv, 89 (1877).—*Herrick.* Final Report, 71 (1884).

Daphnia rectirostris Müller. Entomostraca, 92, t. xii, figs. 1–3 (1785).

Hab.—Minnesota (*Herrick*).

III. Lyncodaphnia Herrick.

1. L. macrothroides Herrick. Amer. Nat. xvi, 1007 (1882); 10th Rep. Geol. Minn. 247 (1882); Final Report, 75 (1884).

Hab.—Minnesota (*Herrick*).

IV. Iliocryptus Sars.

1. I. spinifer Herrick. 10th Rep. Geol. Minn, 246 (1882); Final Report, 77 (1884). Bull. Scientific Lab. Denison University, i, 39 (1885).

Hab.—Minnesota (*Herrick*).

FAMILY LYNCEIDÆ.

I. Eurycercus Baird.

1. E. lamellatus Baird. Ann. and Mag. Nat. Hist. ii, 88, t. ii, figs. 1–8 (1843); British Entomostraca, 124, t. xv, fig. 1 (1850).—*Smith.* Rep. U. S. Fish Com. for 1872–73, 696.—*Birge.* Trans. Wis. Acad. iv, 92 (1877).—*Herrick.* 7th Rep. Geol. Minn. 122 (1879); 10th Rep. Geol. Minn. 248 (1882); Final Report, 80 (1884).

Lynceus lamellatus Müller. Entomostraca, 73, t. ix, figs. 4–6 (1785).

Hab.—Minnesota (*Herrick*), Lake Superior (*Smith*).

II. Acroperus Baird.

1. A. leucocephalus Schödler. Neue Beiträge zur Naturgeschichte der Cladoceren, 30, t, i, figs. 11–16 (1863).—*Birge.* Trans. Wis. Acad. iv, 109 (1877).—*Herrick.* Final Report, 81 (1884).

Lynceus leucocephalus Koch. Deutschlands Crustaceen, h. 36, pl. x (1838).

Hab.—Massachusetts and Wisconsin (*Birge*).

III. CAMPTOCERCUS Baird.

1. C. MACRURUS Baird. Ann. and Mag. Nat. Hist. ii, 91, t. 3, figs. 5, 6 (1843); British Entomostraca, 128, t. xvi, fig. 9 (1850).—*Birge.* Trans. Wis. Acad. iv, 109 (1877).—*Herrick.* 7th Rep. Geol. Minn. 107 (1879); 10th Rep. Geol. Minn. 249 (1882); Final Report, 84 (1884).

Lynceus macrurus Müller. Entomostraca, 77, t. 10, figs. 1–3 (1785).

Hab.—Massachusetts, Wisconsin, and Lake Michigan (*Birge*), Minnesota (*Herrick*).

2. C. ROTUNDUS Herrick. 10th Rep. Geol. Minn. 249 (1882); Final Report, 84 (1884).

Hab.—Minnesota (*Herrick*).

IV. ALONOPSIS Sars.

1. A. LATISSIMA Kurz. Dodekas neuer Cladoceren, 40, t. ii, figs. 13–15 (1874).—*Herrick.* Final Report, 86 (1884).

Hab.—Minnesota (*Herrick*).

2. A. MEDIA Birge. Trans. Wis. Acad. iv, 108 (1877).—*Herrick.* Final Report, 86 (1884).

Hab.—Minnesota (*Herrick*).

V. LEYDIGIA Kurz.

1. L. ACANTHOCERCOIDES Kurz. Dodekas neuer Cladoceren, 53 (1874).—*Herrick.* Final Report, 89 (1884).

L. quadrangularis Herrick. 10th Rep. Geol. Minn. 248 (1882).

Lynceus acanthocercoides Fischer. Bull. Soc. Nat. de Moscou, 1854, 431, t. iii, figs. 21–25.

Hab.—Minnesota (*Herrick*).

2. L. QUADRANGULARIS Kurz. Dodekas neuer Cladoceren, 52, t. ii, fig. 1 (1874).—*Herrick.* Final Report, 88 (1884).

Hab.—Alabama (*Herrick*).

VI. GRAPTOLEBERIS SARS.

1. G. TESTUDINARIA Kurz. Dodekas neuer Cladoceren, 54, t. ii, figs. 11, 12 (1874).—*Herrick.* Final Report, 90 (1884).

G. inermis Birge. Trans. Wis. Acad. iv, 102 (1877).—*Herrick.* 10th Rep. Geol. Minn. 250 (1882).

Lynceus testudinarius Fischer. Bull. Soc. Nat. de Moscou, 1854, t. ix, figs. 1, 2.

Hab.—Massachusetts and Wisconsin (*Birge*), Minnesota (*Herrick*).

VII. CREPIDOCERCUS BIRGE.

1. C. SETIGER Birge. Trans. Wis. Acad. iv, 102 (1877).—*Herrick.* 10th Rep. Geol. Minn. 250 (1882); Final Report, 91 (1884).

Hab.—Wisconsin (*Birge*), Minnesota (*Herrick*).

VIII. ALONA BAIRD.

1. A. AFFINIS Schödler. Neue Beiträge zur Naturgeschichte der Cladoceren, 19 (1883).—*Herrick.* Final Report, 98 (1884).

Lynceus affinis Leydig. Naturgeschichte der Daphniden, 223, t. ix, figs. 68, 69 (1860).

Hab.—Minnesota (*Herrick*).

2. A. ANGULATA Birge. Trans. Wis. Acad. iv, 104 (1877).—*Herrick.* Final Report, 95 (1884).

Hab.—Massachusetts (*Birge*).

3. A. GLACIALIS Birge. Trans. Wis. Acad. iv, 106 (1877).—*Herrick.* Final Report, 100 (1884).

Hab.—Massachusetts (*Birge*).

4. A. LINEATA Schödler. Neue Beiträge zur Naturgeschichte der Cladoceren, 20, t. i, fig. 23 (1863).—*Herrick.* Final Report, 96 (1884).

Lynceus lineatus Fischer. Bull. Soc. Nat. de Moscou, 1854, 429, t. iii, figs. 15, 16.

Hab.—Minnesota (*Herrick*).

5. A. OBLONGA P. E. Müller. Naturhistorisk Tidsskrift, v, 175, pl. iii, figs. 22, 23 (1868).—*Birge*. Trans. Wis. Acad. iv, 107 (1877).—*Herrick*. 10th Rep. Geol. Minn. 250 (1882); Final Report, 97 (1884).

Hab.—Wisconsin (*Birge*), Minnesota (*Herrick*).

6. A. PARVULA, var. TUBERCULATA Herrick. Final Report, 100 (1884).

A. tuberculata Kurz. Dodekas neuer Cladoceren, 51, t. ii, fig. 3 (1874).

Hab.—Massachusetts (*Herrick*).

7. A. PORRECTA Birge. Trans. Wis. Acad. iv, 105 (1877). —*Herrick*. Final Report, 99 (1884).

Hab.—Massachusetts and Wisconsin (*Birge*).

8. A. QUADRANGULARIS Baird. Ann. and Mag. Nat. Hist. ii, 92, t. 3. figs. 9–11 (1843); British Entomostraca, 131, t. xvi. fig. 4 (1859).—*Herrick*. Final Report, 97 (1884).

Lynceus quadrangularis Müller. Entomostraca. 72. t. ix, figs. 1–3.—*Herrick*. 7th Rep. Geol. Minn. 107 (1879).

Hab.—Minnesota (*Herrick*).

9. A. SANGUINEA P. E. Müller. Naturhistorisk Tidsskrift. v, 177 (1868).—*Herrick*. Final Report, 95 (1884).

Hab.—Minnesota (*Herrick*).

10. A. SPINIFERA Schödler. Neue Beiträge zur Naturgeschichte der Cladoceren, 18, pl. i, figs. 17–22 (1863).—*Birge*. Trans. Wis. Acad. iv, 107 (1877).—*Herrick*. Final Report, 99 (1884).

Hab.—Massachusetts and Wisconsin (*Birge*).

IX. ALONELLA SARS.

1. A. EXCISA Kurz. Dodekas neuer Cladoceren, 59 (1874). —*Herrick*. Final Report, 103 (1884).

?*Pleuroxus insculptus* Birge. Trans. Wis. Acad. iv, 95 (1877).

Lynceus excisus Fischer.

Hab.—Massachusetts and Wisconsin? (*Birge*), Minnesota (*Herrick*).

2. A. PULCHELLA Herrick. Final Report, 103 (1884).

Hab.—Minnesota (*Herrick*).

3. A. PYGMÆA Kurz. Dodekas neuer Cladoceren, 61, t. iii, fig. 7 (1874).—*Herrick.* Final Report, 105 (1884).
Hab.—Minnesota? (*Herrick*).

X. PLEUROXUS BAIRD.

1. P. ACUTIROSTRIS Birge. Trans. Wis. Acad. iv, 99 (1877).—*Herrick.* Final Report, 109 (1884).
Hab.—Massachusetts (*Birge*).

2. P. AFFINIS Herrick. Final Report, 111 (1884).
Hab.—Alabama (*Herrick*).

3. P. DENTICULATUS Birge. Trans. Wis. Acad. iv, 98, (1877).—*Herrick.* Final Report, 110 (1884).
Hab.—Massachusetts, Lake Michigan, and Wisconsin (*Birge*), Minnesota and Alabama (*Herrick*).

4. P. HAMATUS Birge. Trans. Wis. Acad. iv, 98 (1877).—*Herrick.* Final Report, 110 (1884).
Hab.—Massachusetts (*Birge*), Alabama (*Herrick*).

5. P. PROCURVUS Birge. Trans. Wis. Acad. iv, 92 (1877).—*Herrick.* 10th Rep. Geol. Minn. 250 (1882); Final Report, 113 (1884).
Hab.—Massachusetts and Wisconsin (*Birge*), Minnesota (*Herrick*).

6. P. STRAMINEUS Birge. Trans. Wis. Acad. iv, 94 (1877).—*Herrick.* Final Report, 108 (1884).
Hab.—Massachusetts (*Birge*).

7. P. UNIDENS Birge. Trans. Wis. Acad. iv, 97 (1877).—*Herrick.* 10th Rep. Geol. Minn. 250 (1882); Final Report, 111 (1884).
Hab.—Wisconsin (*Birge*), Minnesota and Alabama (*Herrick*).

XI. CHYDORUS LEACH.

1. C. CÆLATUS Schödler. Neue Beiträge zur Naturgeschichte der Cladoceren, 15, t. ii, fig. 44 (1863).—*Herrick.* Final Report, 117 (1884).
Hab.—Minnesota (*Herrick*).

2. C. GLOBOSUS Baird. Ann. and Mag. Nat. Hist. ii. 90, t. 3, figs. 1–4 (1843); British Entomostraca, 127, t. xvi, fig. 7. (1850).—*Birge.* Trans. Wis. Acad. iv, 100 (1877).—*Herrick.* Final Report, 116 (1884).

Hab.—Wisconsin (*Birge*), Minnesota (*Herrick*).

3. C. SPHÆRICUS Baird. Ann. and Mag. Nat. Hist. ii, 89, t. 2, figs. 11–13 (1843); British Entomostraca, 126, t. xvi. fig. 8 (1850).—*Birge.* Trans. Wis. Acad. iv, 99 (1877).—*Chambers.* Bull. U.S. Geol. Survey (Hayden), iii, 155 (1877).—*Herrick.* 7th Rep. Geol. Minn. 108 (1879); Final Report, 116 (1884).

Hab.—Massachusetts, Lake Michigan, and Wisconsin (*Birge*), Minnesota (*Herrick*), Kentucky and Colorado (*Chambers*).

XII. MONOSPILUS SARS.

1. M. DISPAR Sars. Crust. Cladoc. i Omgn. af Christiania, 165 (1862).—*Herrick.* Final Report, 119 (1884); Bull. Scientific Lab. Denison Univ. i, 38 (1885).

Hab.—Minnesota (*Herrick*).

FAMILY POLYPHEMIDÆ.

I. POLYPHEMUS MÜLL.

1. P. PEDICULUS De Geer. Mem. pour serv. a l'histoire Ins. vii, 467, t. 28, figs. 9–13 (1778).—*Birge.* Trans. Wis. Acad. iv, 109 (1877).—*Herrick.* 10th Rep. Geol. Minn. 251 (1882); Final Report, 121 (1884).

Monoculus pediculus Linnæus. Syst. Nat. (12th Ed.) i. 1058 (1767).

Polyphemus oculus Müller. Entomostraca, 119, t, 20, figs. 1–5 (1785).

P. occidentalis Herrick. 7th Rep. Geol. Minn. 122 (1879).

Hab.—Massachusetts (*Birge*), Minnesota (*Herrick*).

2. P. STAGNALIS Herrick. Final Report, 122 (1884).

Hab.—Minnesota? (*Herrick*).

FAMILY LEPTODORIDÆ.

I. LEPTODORA LILLJEB.

1. L. HYALINA Lilljeborg. Ofversigt af Vetens.-Akad. Förhandl., 1860, 265, pl. vii, figs. 1–22.—*Smith.* Rep. U. S. Fish Com. for 1872–73, 696.—*Forbes.* Amer. Nat. xvi. 641 (1882).—*Herrick.* Final Report, 123 (1884).

Hab.—Lake Michigan (*Forbes*), Lake Superior (*Smith*).

ORDER PHYLLOPODA.

FAMILY LIMNADIDÆ.

I. LIMNETIS LOVEN.

1. L. BREVIFRONS Packard. Bull. U. S. Geol. Survey (Hayden), iii, 172 (1877); 12th Rep. U. S. Geol. Survey (Hayden), ii, 301 (1883).

Hab.—Kansas.

2. L. GOULDII Baird. Ann. and Mag. Nat. Hist. 3d ser., x, 393 (1862).—*Packard.* 7th Rep. U. S. Geol. Survey (Hayden), 618 (1874); Bull. U. S. Geol. Survey (Hayden), iii, 173 (1877); 12th Rep. U. S. Geol. Survey (Hayden), ii, 299 (1883).—*Herrick.*

Hab.—New Hampshire, Massachusetts, Rhode Island, New York, Illinois, Canada.

3. L. GRACILICORNIS Packard. Amer. Jour. Science, 3d ser., ii, 113 (1871); 7th Rep. U. S. Geol. Survey (Hayden), 618 (1874); 12th Rep. U. S. Geol. Survey (Hayden), ii, 302 (1883).

Hab.—Texas.

4. L. MUCRONATUS Packard. Amer. Nat. ix, 312 (1875); Bull. U. S. Geol. Survey (Hayden), iii, 172 (1877); 12th Rep. U. S. Geol. Survey (Hayden), ii, 300 (1883).

Hab.—Kansas, Montana.

II. ESTHERIA RÜPP.

1. E. BELFRAGEI Packard. Amer. Jour. Science, 3d. ser., ii, 112 (1871); 7th Rep. U. S. Geol. Survey (Hayden), 619 (1874); 12th Rep. U. S. Geol. Survey (Hayden), ii, 309 (1883).

Hab.—Texas.

2. E. CALIFORNICA Packard. 6th Rep. Peabody Acad. Science, 55 (1874); 7th Rep. U. S. Geol. Survey (Hayden), 618 (1874); 12th Rep. U. S. Geol. Survey (Hayden), ii, 304 (1883).

Hab.—California.

3. E. COMPLEXIMANUS Packard. 12th Rep. U. S. Geol. Survey (Hayden), ii, 305 (1883).

Eulimnadia complerimanus Packard. Bull. U. S. Geol. Survey (Hayden), iii, 174 (1877).

Hab.—Kansas.

4. E. JONESII Baird. Proc. Zoöl. Soc. London, 147, pl. xv, figs. 1a, 1b, 1c, 1d (1862).—*Packard.* 7th Rep. U. S. Geol. Survey (Hayden), 619 (1874); 12th Rep. U. S. Geol. Survey (Hayden), ii, 310 (1883).

Hab.—Southern States? Cuba.

5. E. MEXICANA Claus. Beiträge zur Kennt. d. Entomostraken, t. iii, iv, figs. 33-54 (1860).—*Packard.* 12th Rep. U. S. Geol. Survey (Hayden), ii, 306 (1883).

E. clarkii Packard. 6th Rep. Peabody Acad. Science, 55, (1874); 7th Rep. U. S. Geol. Survey (Hayden), 619 (1874).

Hab.—Lake Winnepeg, Kentucky, Ohio, Kansas, New Mexico, Mexico.

6. E. MORSEI Packard. Amer. Jour. Science, 3d ser., ii, 113 (1871); 6th Rep. Peabody Acad. Science, 56 (1874); 7th Rep. U. S. Geol. Survey (Hayden), 619 (1874); 12th Rep. U. S. Geol. Survey (Hayden), ii, 308 (1883).

Hab.—Iowa, Dakota.

III. EULIMNADIA PACKARD.

1. E. AGASSIZII Packard. 6th Rep. Peabody Acad. Science, 54 (1874); 7th Rep. U. S. Geol. Survey (Hayden), 618 (1874); 12th Rep. U. S. Geol. Survey (Hayden), ii, 311 (1883).

Hab.—Penikese Island (Massachusetts).

2. E. TEXANA Packard. 12th Rep. U. S. Geol. Survey (Hayden), ii, 312 (1883).

Limnadia texana Packard. Amer. Jour. Science, 3d ser., ii, 111 (1871); 7th Rep. U. S. Geol. Survey (Hayden), 618 (1874).

Hab.—Kansas, Texas.

IV. LIMNADELLA GIRARD.

1. L. CORIACEA Haldeman. Proc. Phila. Acad. 1842, 184; Ibid. 1854, 34.—*Packard.* 7th Rep. U. S. Geol. Survey (Hayden), 618 (1874); 12th Rep. U. S. Geol. Survey (Hayden), ii, 313 (1883).

Unrecognizable from description.

Hab.—Pennsylvania (*Haldeman*).

2. L. KITEI Girard. Proc. Phila. Acad. 1854, 3.—*Packard.* 12th Rep. U. S. Geol. Survey, ii, 311 (1883).

Unrecognizable from description.

Hab.—Ohio (*Girard*).

V. LIMNADIA BRONG.

1. L. AMERICANA Morse. Proc. Boston Soc. N. H., xi, 404 (1868).—*Packard.* 7th Rep. U. S. Geol. Survey (Hayden), 618 (1874); 12th Rep. U. S. Geol. Survey (Hayden), ii, 311 (1883).

Hab.—Massachusetts.

FAMILY APODIDÆ.

I. APUS SCHÄFF.

1. A. ÆQUALIS Packard. Amer. Jour. Science, 3d ser., ii, 110 (1871); 7th Rep. U. S. Geol. Survey (Hayden), 620 (1874); 12th Rep. U. S. Geol. Survey (Hayden), ii, 320 (1883).

Hab.—Kansas, Texas, Colorado?

2. A. LONGICAUDATUS Le Conte. Annals N. Y. Lyceum, iv, 155 (1845).—*Packard.* 12th Rep, U. S. Geol. Survey (Hayden), ii, 324 (1883).

A. obtusus James. Long's Expedition, ii, 336 (1823).—*Packard.* 7th Rep. U. S. Geol. Survey (Hayden), 620 (1874).

Hab.—Colorado, Wyoming, Kansas.

3. A. LUCASANUS Packard. Amer. Jour. Science, 3d ser., ii, 109 (1871); 7th Rep. U. S. Geol. Survey (Hayden), 620 (1874); Bull. U. S. Geol. Survey (Hayden), iii, 179 (1877); 12th Rep. U. S. Geol. Survey (Hayden), ii, 321 (1883).

Hab.—Kansas, Lower California.

4. A. NEWBERRYI Packard. Amer. Jour. Science, 3d ser., ii, 109 (1871); 7th Rep. U. S. Geol. Survey (Hayden), 620 (1874); 12th Rep. U. S. Geol. Survey (Hayden), ii, 321 (1883).

Hab.—Utah.

II. LEPIDURUS LEACH.

1. L. BILOBATUS Packard. Bull. U. S. Geol. Survey (Hayden), iii, 178 (1877); 12th Rep. U. S. Geol. Survey (Hayden), ii, 318 (1883).

Hab.—Colorado.

2. L. COUESII Packard. Amer. Nat. ix, 311 (1875); Bull. U. S. Geol. Survey (Hayden), iii, 177 (1877); 12th Rep. U. S. Geol. Survey (Hayden), ii, 317 (1883).

Hab.—Utah, Montana.

3. L. GLACIALIS Kroyer. Naturhistorisk Tidsskrift, 2d ser., ii, 431 (1847).—*Packard.* 7th Rep. U. S. Geol. Survey (Hayden), 619 (1874); 12th Rep. U.S. Geol. Survey (Hayden), ii, 316 (1883).

Hab.—Arctic America, Greenland.

FAMILY BRANCHIPODIDÆ.

I. ARTEMIA LEACH.

1. A. GRACILIS Verrill. Amer. Jour. Science, 2d ser., xlviii, 248, 249, 430 (1869); Proc. A. A. A. S. for 1869, 235 238.—*Packard.* 7th Rep. U. S. Geol. Survey (Hayden), 620, 621 (1874); 12th Rep. U. S. Geol. Survey (Hayden), ii, 330 (1883).

A. monica Verrill. Amer. Jour. Science, 2d ser., xlviii, 248 (1869).

A. fertilis Verrill. Amer. Jour. Science, 2d series., xlviii, 248 (1869).

A. utahensis Lockington. Monthly Micros. Jour. 1876, 137, *fide* Packard.

Hab.—Connecticut, Utah.

II. BRANCHINECTA VERRILL.

1. B. COLORADENSIS Packard. 7th Rep. U. S. Geol. Survey (Hayden), 621 (1874); 12th Rep. U. S. Geol. Survey (Hayden), ii, 338 (1883).

Hab.—Colorado.

2. B. LINDAHLI Packard. 12th Rep. U. S. Geol. Survey (Hayden), ii, 339 (1883).

Hab.—Kansas.

3. B. PALUDOSA Packard. 12th Rep. U. S. Geol. Survey (Hayden), ii, 336 (1883).

B. grœnlandica Verrill. Amer. Jour. Science, 2d ser., xlviii, 253 (1869); Proc. A. A. A. S. for 1869, 244.—*Packard.* 7th Rep. Geol. Survey (Hayden), 621 (1874).

B. arctica Verrill. Amer. Jour. Science, 2d ser., xlviii, 253 (1869); Proc. A. A. A. S. for 1869, 244.—*Packard.* 6th Rep. U. S. Geol. Survey (Hayden), 621 (1874).

Branchipus paludosus Müller.

Hab.—Labrador, Arctic America, Greenland.

III. BRANCHIPUS SCHÄFF.

1. B. BUNDYI Forbes.

Eubranchipus bundyi Forbes. Bull. Ill. St. Lab. N. H., i, 25 (1876).

Hab.—Wisconsin (*Forbes*).

2. B. SERRATUS Forbes.

Eubranchipus serratus Forbes. Bull. Ill. St. Lab. N. H., i, 13 (1876).—*Packard.* 12th Rep. U. S. Geol. Survey (Hayden), ii, 343 (1883).

Hab.—Illinois (*Forbes*).

3. B. VERNALIS Verrill. Amer. Jour. Science, 2d ser., xlviii, 25 (1869); Proc. A. A. A. S. for 1869, 622.—*Packard.* 7th Rep. U. S. Geol. Survey (Hayden), 622 (1874); 12th Rep. U. S. Geol. Survey (Hayden), ii, 342 (1883).—*Gissler.* Amer. Nat. xv, 136 (1881).—*Hay.* Amer. Nat. xvi, 242 (1882).

Hab. Massachusetts, Rhode Island, Connecticut, New York, Pennsylvania, Ohio, Indiana.

IV. CHIROCEPHALUS PREVOST.

1. C. HOLMANI Ryder. Proc. Phila. Acad. 1879, 148.—*Packard.* 12th Rep. U. S. Geol. Survey (Hayden), ii, 351 (1883).—*Herrick.* Bull. Scientific Lab. Denison Univ. i, 19 (1885).

Hab.—New York, Pennsylvania, Minnesota.

V. STREPTOCEPHALUS BAIRD.

1. S. FLORIDANUS Packard. Amer. Nat. xiv, 53 (1880); 12th Rep. U. S. Geol. Survey (Hayden), ii, 350 (1883).

Hab.—Florida.

2. S. SEALII Ryder. Proc. Phila. Acad. 1879, 200.—*Packard.* 12th Rep. U. S. Geol. Survey (Hayden), ii, 348 (1883).

Hab.—New York, New Jersey.

3. S. TEXANUS Packard. Amer. Jour. Science, 3rd ser., ii, 111 (1871); 7th Rep. U.S. Geol. Survey (Hayden), 622 (1874); 12th Rep. U.S. Geol. Survey (Hayden), ii, 345 (1883).

S. Watsoni Packard. Bull. U. S. Geol. Survey (Hayden), iii, 176 (1877).

Hab.—Kansas, Texas.

VI. THAMNOCEPHALUS PACKARD.

1. T. PLATYURUS Packard. Bull. U.S. Geol. Survey (Hayden), iii, 175 (1877); 12th Rep. U. S. Geol. Survey (Hayden), ii, 353 (1883).

Hab.—Kansas.

ORDER AMPHIPODA.

FAMILY GAMMARIDÆ.

I. CRANGONYX BATE.

1. C. ANTENNATUM Packard. Amer. Nat. xv, 880 (1881).
Hab.—Tennessee (*Packard*).

2. C. BIFURCUS Hay. Amer. Nat. xvi, 144 (1882).
Hab.—Mississippi (*Hay*).

3. C. GRACILIS Smith. Amer. Jour. Science, 3rd ser., ii, 453 (1871); Rep. U. S. Fish Com. for 1872-73, 654, 694.—*Forbes.* Bull. Ill. State Lab. N. H. No. 1, 6 (1876).—*Hay.* Amer. Nat. xvi, 241 (1882).
Hab.—Indiana (*Hay*), Illinois (*Forbes*), Lake Superior and Lake Huron (*Smith*).

4. C. LUCIFUGUS Hay. Amer. Nat. xvi, 144 (1882).
Hab.—Illinois (*Hay*).

5. C. MUCRONATUS Forbes. Bull. Ill. State Lab. N. H., No. 1, 6 (1876).—*Hay.* Amer. Nat. xvi, 241 (1882).
Hab.—Indiana (*Hay*), Illinois (*Forbes*).

6. C. PACKARDII Smith. Amer. Jour. Science, 3rd ser., ix, 476–7 (1875).
C. vitreus Packard. 5th Rep. Peabody Acad. Science, 95 (1873).
Hab.—Indiana (*Packard*).

7. C. TENUIS Smith. Rep. U. S. Fish Com. for 1872–73, 656.
Hab.—Connecticut (*Smith*).

8. C. VITREUS Smith. Rep. U. S. Fish Com. for 1872–73, 656; Amer. Jour. Science, 3rd ser., ix, 476–7 (1875).
Stygobromus vitreus Cope. Amer. Nat. vi, 422 (1872); 3rd and 4th Rep. Geol. Indiana, 181 (1872).
Hab.—Mammoth Cave, Kentucky (*Cope*).

II. GAMMARUS FABR.

1. G. APPENDICULATUS Say. Jour. Phila. Acad. i, 379 (1817).—*DeKay.* Nat. Hist. N. Y., vi, 37 (1844).
Hab.—Georgia (*Say*).

2. G. FASCIATUS Say. Jour. Phila. Acad. i, 379 (1817).—*DeKay.* Nat. Hist. N. Y. vi, 37 (1844).—*Smith.* Rep. U. S. Fish Com. for 1872–73, 653.—*Forbes.* Bull. Ill. State Lab. N. H., No. 1, 6 (1876).

Hab.—Maine (*Verrill*), Connecticut (*Smith*), Pennsylvania (*Say*), Illinois (*Forbes*), Michigan (*Milner*), Wisconsin (*Verrill*).

3. G. LIMNÆUS Smith. Rep. U. S. Fish Com. for 1872–73, 651, 694; 7th Rep. U. S. Geol. Survey (Hayden), 609 (1874).

G. lacustris Smith. Amer. Jour. Science, 3rd ser., ii, 453 (1871).

Hab.—Michigan, Lake Superior and Colorado (*Smith*).

4. G. MINUS Say. Jour. Phila. Acad. i, 374 (1817).—*DeKay.* Nat. Hist. N. Y. vi, 37 (1844).—*Gould.* Invertebrata of Massachusetts, 334 (1841).—*Smith.* Rep. U. S. Fish Com. for 1872–73, 654.

Hab.—New York(?).

5. G. ROBUSTUS Smith. 7th Rep. U.S. Geol. Survey (Hayden), 610 (1874).

Hab.—Colorado (*Smith*).

FAMILY LYSIANASSIDÆ.

I. PONTOPOREIA KRÖYER.

1. P. FILICORNIS Smith. Rep. U. S. Fish Com. for 1872–83, 649.—*Forbes.* Bull. Ill. State Lab. N. H., No. 1, 20 (1876).

Gammarus filicornis Stimpson MSS.

Hab.—Lake Michigan (*Stimpson*).

2. P. HOYI Smith. Rep. U. S. Fish Com. for 1872–73, 647, 694.—*Forbes.* Bull. Ill. State Lab. N. H., No. 1, 20 (1876).

P. affinis Smith. Amer. Jour. Science, 3rd ser., ii, 452 (1871).

Gammarus Hoyi Stimpson MSS.

Gammarus brevistylus Stimpson MSS.

Hab.—Lake Michigan (*Stimpson*), Lake Superior (*Smith*).

FAMILY ORCHESTIDÆ.

I. ALLORCHESTES HELLER.

1. A. DENTATUS Faxon. Bull. Mus. Comp. Zoöl., iii, 373, (1876).

Hyalella dentata Smith. Rep. U. S. Fish Com. for 1872–73, 645, 694; 7th Rep. U.S. Geol. Survey (Hayden), 611 (1874). —*Forbes.* Bull. Ill. State Lab. N. H.. No. 1, 5 (1876).

?*Amphitœ Aztecus* Saussure. Mem. sur divers Crust. nouv. du Mexique et des Antilles, 58 (1858).

?*Allorchestes Knickerbockeri* Bate. Cat. Amphip. Crust. Brit. Mus., 36 (1862).

Hab.—Maine, Massachusetts, Connecticut, Florida, Illinois, Wisconsin, Iowa, Michigan, Nebraska, Colorado, Oregon, Lake Superior.

Var. INERMIS Faxon. Bull. Mus. Comp. Zoöl., iii, 373 (1876).

Hyalella inermis Smith. 7th Rep. U. S. Geol. Survey (Hayden), 610 (1874).

Hab.—Colorado (*Smith*).

ORDER ISOPODA.

FAMILY ASELLIDÆ.

I. ASELLUS GEOFF.

1. A. BREVICAUDA Forbes. Bull. Ill. State Lab. N. H., No. 1, 8 (1876).

Hab.—Illinois (*Forbes*).

2. A. COMMUNIS Say. Jour. Phila. Acad., i, 428 (1817). —*DeKay.* Nat. Hist. N. Y., vi, 49 (1844).—*Smith.* Rep. U. S. Fish Com. for 1872–73, 657.—*Hay.* Amer. Nat. xvi, 241 (1882).

?*A. vulgaris* Gould. Invertebrata of Massachusetts, 337 (1841).

A. militaris Hay. Bull. Ill. State Lab. N. H., No. 2, 90 (1878).

Hab.—Connecticut, Massachusetts, New York, Pennsylvania, Indiana, Illinois, Michigan, Mississippi.

3. A. INTERMEDIUS Forbes. Bull. Ill. State Lab. N. H., No. 1, 10 (1876).

Hab.—Illinois (*Forbes*).

4. A. LINEATUS Say. Jour. Phila. Acad., i, 428 (1817).—*DeKay.* Nat. Hist. N. Y., vi, 50 (1844).

Hab.—South Carolina (*Say*).

5. A. STYGIUS Forbes. Bull. Ill. State Lab. N. H., No. 1, 11 (1876).

Cæcidotea stygia Packard. Amer. Nat., v, 751 (1871); 5th Rep. Peabody Acad. Science, 95 (1873).—*Smith.* Rep. U. S. Fish Com. for 1872–73, 661.—*Hubbard.* Amer. Entomologist, n. ser., i, 36, 79 (1880).

C. microcephala Cope. Amer. Nat., vi, 411 (1872); 3rd and 4th Rep. Geol. Indiana, 163 (1872).—*Smith.* Amer. Nat., vii, 244 (1873).

Hab.—Indiana (*Cope*), Illinois (*Forbes*), Kentucky (*Packard*).

II. CÆCIDOTEA PACKARD.

1. C. NICKAJACKENSIS Packard. Amer. Nat., xv, 879 (1881).

Hab.—Tennessee (*Packard*).

III. MANCASELLUS HARGER.

1. M. BRACHYURUS Harger. Amer. Jour. Science, 3rd ser., xi, 304, 305 (1876).

Hab.—Virginia (*Harger*).

2. M. TENAX Harger. Amer. Jour. Science, 3rd ser., xi, 304 (1876).—*Hay.* Amer. Nat., xvi, 242 (1882).

Asellus tenax Smith. Amer. Jour. Science, 3rd ser., ii, 453 (1871).

Asellopsis tenax Harger. Amer. Jour. Science, 3rd ser., vii, 601 (1874).—*Smith.* Rep. U. S. Fish Com. for 1872–73, 659, 695.

Hab.—Indiana (*Hay*), Michigan and Lake Huron (*Milner*), Lake Superior (*Smith*).

FAMILY ONISCIDÆ.*

I. ACTONISCUS HARGER.

1. A. ELLIPTICUS Harger. Amer. Jour. Science, 3rd ser., xv, 373 (1878); Proc. U. S. Nat. Museum, ii, 157 (1879); Rep. U. S. Fish Com. for 1878, 309.
Hab.—Connecticut (*Harger*).

II. ALLONISCUS DANA.

1. A. PERCONVEXUS Dana. Proc. Phila. Acad., vii, 176 (1854).
Hab.—California (*Dana*).

III. ARMADILLO LATR.

1. A. SPECIOSUS Stuxberg. Öfversigt af Vetensk.-Akad. Förhandl., 1875, No. 2, 62.
Hab.—California (*Stuxberg*).

IV. ARMADILLIDIUM BRANDT.

1. A. PILULARE Stuxberg. Öfversigt af Vetensk.-Akad. Förhandl., 1875, No. 2, 63.

Armadillo pilularis Say. Jour. Phila. Acad., i, 432 (1817).—*Gould*. Invertebrata of Massachusetts, 336 (1841).—*DeKay*. Nat. Hist. N. Y., vi, 54 (1844).

Hab.—Massachusetts (*Gould*), New York (*DeKay*), Pennsylvania (*Say*).

V. LIGIA FABR.

1. L. DILATATA Stimpson. Proc. Boston Soc. N. H., vi, 88 (1857); Boston Jour. Nat. Hist., vi, 507 (1857).
Hab.—Washington Territory (*Stimpson*).

2 L. OCCIDENTALIS Dana. Crustacea, ii, 742 (1853).
Hab.—California (*Dana*).

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* A few forms of *Oniscidæ* are found only at or near the sea coast, and should properly take rank among the marine species. The entire family, however, as known from America is indexed here.

3. L. PALLASII Brandt. Conspectus Oniscodorum, 172 (1833).
Hab. Unalaska (*Brandt*).

VI. LIGIDIUM BRANDT.

1. L. HYPNORUM Budde-Lund. Naturhistorisk Tidsskrift, 3rd ser., vii, 225 (1870).—*Stuxberg.* Öfversigt af Vetensk.-Akad. Förhandl., 1875, No. 2, 48.
Oniscus hypnorum Cuvier (1792).
Hab.—Niagara in Canada, and California (*Eisen*).

VII. ONISCUS L.

1. O. AFFINIS Say. Jour. Phila. Acad., i, 430 (1817).
Hab.—Pennsylvania (*Say*).

2. O. VICARIUS Stuxberg. Öfversigt af Vetensk.-Akad. Förhandl., 1872, No. 9, 3; Ibid. 1875, No. 2, 50.
Hab. Newfoundland (*Lindahl*), Canada near Niagara (*Eisen*).

VIII. PHILOSCIA LATR.

1. P. SPINOSA Say. Jour. Phila. Acad., i, 429 (1817).—*DeKay.* Nat. Hist. N. Y., vi, 50 (1884).
Hab.—Georgia (*Say*).

2. P. VITTATA Say. Jour. Phila. Acad., i, 429 (1817).—*DeKay.* Nat. Hist. N. Y., vi, 50 (1844).—*Harger.* Rep. U.S. Fish Com. for 1871, 569; Proc. U. S. Nat. Museum, ii, 157 (1879); Rep. U. S. Fish Com. for 1878, 306.
Hab.—New Jersey, Connecticut and Massachusetts (*Harger*).

IX. EUPHILOSCIA PACKARD.

1. E. ELRODII Packard. 5th Rep. Peabody Acad. Science, 97 (1873).—*Smith.* Amer. Jour. Science, 3rd ser., ix, 477 (1875).
Hab.—Indiana (*Packard*).

X. PORCELLIO LATR.

1. P. CONVEXUS Johnsson. Sveriges Oniscider, 32 (1868).—*Stuxberg.* Öfversigt af Vetensk.-Akad. Förhandl., 1875, No. 2, 60.

Oniscus convexus DeGeer (1778).

Hab.—Massachusetts, and Canada near Niagara (*Eisen*).

2. P. DUBIUS Brandt. Conspectus Oniscodorum, 178 (1833).

Hab.—? [This species is cited by Stuxberg *loc. cit.* 58.]

3. P. FORMOSUS Stuxberg. Öfversigt af Vetensk.-Akad. Förhandl., 1875, No. 2, 57.

Hab.—California (*Eisen*).

4. P. GEMMULATUS Dana. Crustacea, 725, t. 47, fig. 7 (1853).

Hab.—Washington Territory (*Dana*).

5. P. GLABER Fitch. Trans. N. Y. State Agric. Soc. 1854, 824; First and Second Rep. on Insects, 120 (1856).

Hab.—New York (*Fitch*).

6. P. IMMACULATUS Fitch. Trans. N. Y. State Agric. Soc. 1854, 824; First and Second Rep. on Insects, 120 (1856).

Hab.—Illinois and Arkansas (*Fitch*).

7. P. LIMATUS Fitch. Trans. N. Y. State Agric. Soc. 1854, 824; First and Second Rep. on Insects, 120 (1856).

Hab.—New York (*Fitch*).

8. P. MACULICORNIS Koch. Deutschlands Crustaceen, 34, 16 (1840).—*Stuxberg.* Öfversigt af Vetensk.-Akad. Förhandl. 1875, No. 2, 55.

Hab.—California (*Eisen*).

9. P. MIXTUS Fitch. Trans. N. Y. State Agric. Soc. 1854, 824; First and Second Report on Insects, 120 (1856).

Hab.—New York (*Fitch*).

10. P. NIGER Say. Jour. Phila. Acad. i, 432 (1817).—*De-Kay.* Nat. Hist. N. Y., vi, 52 (1844).

Hab.—Pennsylvania (*Say*).

11. P. PICTUS Brandt. Conspectus Oniscodorum, 176 (1833).—*Stuxberg.* Öfversigt af Vetensk.-Akad. Förhandl., 1875, No. 2, 59.

Hab.—Canada near Niagara (*Eisen*).

12. P. SCABER Latreille. Hist. Nat. Crust. et Insectes, vii, 45, in part (1804).—*Fitch.* Trans. N. Y. State Agric. Soc. 1854, 825; First and Second Report on Insects, 121 (1856).—*Stuxberg.* Öfversigt af Vetensk.-Akad. Förhandl. 1875, No. 2, 58.

Oniscus asellus Linnæus. Syst. Nat., Ed. 10, i, 637 (1758).—*Gould.* Invertebrata of Massachusetts, 326 (1841).—*DeKay.* Nat. Hist. N. Y., vi, 51 (1844).

Hab.—Illinois (*Fitch*), Canada near Niagara, and California (*Eisen*), Newfoundland (*Lindahl*).

13. P. SPINICORNIS Say. Jour. Phila. Acad., i, 431 (1817).

Hab.—North America (*Say*).

14. P. TRILINEATUS Koch. Deutschlands Crustaceen, 34, 9 (1840).—*Stuxberg.* Öfversigt af Vetensk.-Akad. Förhandl. 1875, No. 2, 59.

Hab.—Massachusetts and Canada near Niagara (*Eisen*).

15. P. VITTATUS Fitch. Trans. N. Y. State Agric. Soc. 1854, 814; First and Second Report on Insects, 120 (1856).

Hab.—New York (*Fitch*).

XI. RHINORYCTES STUXBERG.

1. R. MIRABILIS Stuxberg. Öfversigt af Vetensk.-Akad. Förhandl. 1875, No. 2, 51.

Hab.—California (*Eisen*).

XII. SCYPHACELLA SMITH.

1. S. ARENICOLA Smith. Rep. U. S. Fish Com. for 1871, 568.—*Harger.* Proc. U. S. Nat. Museum, ii, 157 (1879); Rep. U. S. Fish Com. for 1878, 307.

Hab.—Massachusetts and New Jersey (*Harger*).

XIII. Sphærillo Dana.

1. S. affinis Dana. Proc. Phila. Acad. vii, 176 (1854).
Hab.—California (*Dana*).

XIV. Styloniscus Dana.

1. S. gracilis Dana. Proc. Phila. Acad. vii, 176 (1854).
Hab.—California (*Dana*).

XV. Trichoniscus Brandt.

1. T. pusillus Brandt. Conspectus Oniscodorum, 174 (1833).—*Stuxberg.* Öfversigt af Vetensk.-Akad. Förhandl. 1875, No. 2, 49.

Hab.—Canada near Niagara (*Eisen*).

ORDER DECAPODA.

FAMILY MYSIDÆ.

I. Mysis Latr.

1. M. relicta Loven. Öfversigt af Vetensk.-Akad. Förhandl. xviii, 285 (1861).—*Smith.* Amer. Jour. Science, 3rd ser., ii, 452 (1872); Rep. U. S. Fish Com. for 1872–73, 642, 694. —*Forbes.* Bull. Ill. State Lab. N. H., No. 1, 20 (1876).

M. diluvianus Stimpson MSS.

Hab.—Lake Michigan (*Stimpson*), Lake Superior (*Smith*).

FAMILY ASTACIDÆ.

I. Astacus Fabr.

1. A. Gambellii Agassiz. Proc. Phila. Acad. vi, 375 (1853). —*Stimpson.* Jour. Boston Soc. N. H., vi, 492 (1857); Proc. Boston Soc. N. H., vi, 87 (1857).—*Hagen.* Monog. Astacidæ, 90, pl. i, figs. 97, 98, pl. iii, fig. 170, pl. xi (1870).—*Faxon.* Proc. Amer. Acad. xx, 152 (1884); Revision of Astacidæ, 136 (1885).

Hab.—Utah, Idaho, Montana, Wyoming? California?

2. A. KLAMATHENSIS Stimpson. Proc. Boston Soc. N. H., vi, 87 (1857); Jour. Boston Soc. N. H., vi, 494 (1857).—*Hagen.* Monog. Astacidæ, 93, pl. iii, 169 (1870).—*Faxon.* Proc. Amer. Acad. xx, 151 (1884); Revision of Astacidæ, 131, pl. vi, figs. 1, 2 (1885).

Hab.—Oregon, Washington Territory, British Columbia.

3. A. LENIUSCULUS Dana. Proc. Phila. Acad. vi, 20 (1852); Crustacea, i, 524, pl. xxxiii, fig. 1 (1852).—*Stimpson.* Jour. Boston Soc. N. H., vi, 493 (1857); Proc. Boston Soc. N. H. 87 (1857).—*Hagen.* Monog. Astacidæ, 94 (1870).—*Faxon.* Proc. Amer. Acad. xx, 151 (1884); Revision of Astacidæ, 132, pl. vi, fig. 4 (1885).

?*A. Oreganus* Randall. Jour. Phila. Acad. viii, 138, pl. vii (1839).—*Stimpson.* Proc. Boston Soc. N. H., vi, 87 (1852).—*Hagen.* Monog. Astacidæ, 95 (1870).—*Faxon.* Revision of Astacidæ, 133 (1885).

Hab.—Washington Territory

4. A. NIGRESCENS Stimpson. Proc. Boston Soc. N. H., vi, 87 (1852); Jour. Boston Soc. N. H., vi, 492 (1852).—*Hagen.* Monog. Astacidæ, 92, pl. iii, fig. 168 (1870).—*Faxon.* Proc. Amer. Acad. xx, 152 (1884); Revision of Astacidæ, 135 (1885).

Hab.—California, Washington Territory.

5. A. TROWBRIDGII Stimpson. Proc. Boston Soc. N. H., vi, 87 (1857); Jour. Boston Soc. N. H., vi, 492 (1857).—*Hagen.* Monog. Astacidæ, 93, pl. iii, fig. 171, pl. x, (1870).—*Faxon.* Proc. Amer. Acad. xx, 152 (1884); Revision of Astacidæ, 134, (1885).

Hab.—Oregon, Washington Territory.

II. CAMBARUS ERICH.

1. C. ACUMINATUS Faxon. Proc. Amer. Acad. xx, 113 (1884); Revision of Astacidæ, 67, pl. iii, fig. 5, pl. viii, fig. 6a, 6a′ (1885).

Hab.—North Carolina, South Carolina.

2. C. ADVENA Hagen. Monog. Astacidæ, pl. iii, fig. 164, pl. viii (1870).—*Faxon.* Proc. Amer. Acad. xx, 140 (1884); Revision of Astacidæ, 54 (1885).

C. Carolinus Hagen. Monog. Astacidæ, 87, pl. i, figs. 51–54, pl. iii. fig. 165 (1870).

Astacus advena Le Conte. Proc. Phila. Acad. vii, 402 (1885).

Hab.—South Carolina, Georgia, Alabama.

3. C. AFFINIS Girard. Proc. Phila. Acad. vi, 81 (1852). —*Hagen.* Monog. Astacidæ, 60, pl. i, figs. 19–22, 84, 85, pl. iii, fig. 152, pl. v (1870).—*Faxon.* Proc. Amer. Acad. xx, 146 (1884); Revision of Astacidæ, 86 (1885).

C. Pealei Girard, l. c. 87 (1852).

Astacus affinis Say. Jour. Phila. Academy, i, 168 (1817). —*Harlan.* Med. and Phys. Res., 230, fig. 2 (1835).—*DeKay.* Nat. Hist. N. Y., vi, 22 (1844).

Hab.—New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Virginia, Lake Erie, Lake Superior.

4. C. ALABAMENSIS Faxon. Proc. Amer. Acad. xx, 125, 146 (1884); Revision of Astacidæ. 104, pl. iv, fig. 4, pl. x, figs. 3, 3′, 3a, 3a′ (1885).

Hab.—Alabama.

5. C. ALLENI Faxon. Proc. Amer. Acad. xx, 110, 138 (1884); Revision of Astacidæ, 35, pl. i, fig. 1, pl. viii, figs. 2, 2′ (1885).

Hab.—Florida.

6. C. ANGUSTATUS Hagen. Monog. Astacidæ, 50, pl, i, figs. 65–67, pl. iii, fig. 146 (1870).—*Faxon.* Proc. Amer. Acad. xx, 137 (1884); Revision of Astacidæ, 30 (1885).

Astacus angustatus Le Conte. Proc. Phila. Acad. vii, 401 (1885).

Hab.—Georgia.

7. C. ARGILLICOLA Faxon. Proc. Amer. Acad. xx, 115, 144 (1884); Revision of Astacidæ, 76, pl. iv, fig. 2 (1885).

Hab.—Ontario, Michigan, Indiana, Louisiana? North Carolina?

8. C. BARTONII Girard. Proc. Phila. Acad. vi, 88 (1852). *Hagen.* Monog. Astacidæ, 75, pl. i, figs. 47–50, pl. ii, figs. 135–139, pl. iii, fig. 166 (1870).– *Faxon.* Proc. Amer. Acad. xx, 142 (1884); Revision of Astacidæ, 59 (1885).

C. montanus Girard, l. c. 88 (1852).

?*C. longulus* Girard, l. c. 90 (1852).

?*C. pusillus* Girard. l. c. 90 (1852).

Astacus Bartonii Say. Jour. Phila. Acad. i, 167 (1817).—*Harlan.* Med. and Phys. Res. 230, fig. 3 (1835).—*Gould.* Invertebrata of Massachusetts, 330 (1841).—*Thompson.* History of Vermont, Part I, 170 (1842).—*DeKay.* Nat. Hist. N. Y., vi, 22, pl. viii, fig. 25 (1844).

Hab.—New Brunswick, Province of Quebec? Maine, Vermont, Massachusetts, New York, New Jersey, Maryland, Virginia, West Virginia, North Carolina, Ohio, Indiana, Kentucky, Tennessee, Lake Superior.

Var. ROBUSTA Faxon. Revision of Astacidæ, 61 (1885).

C. robustus Girard. Proc. Phila. Acad. vi, 90 (1852).—*Hagen.* Monog. Astacidæ, 80, pl. iii, fig. 167 (1870).—*Faxon.* Proc. Amer. Acad. xx, 143 (1884).

Hab.—Province of Ontario, New York, Maryland, Virginia, Illinois.

9. C. BLANDINGII Hagen. Monog. Astacidæ, 43, pl. i, figs. 63–64, pl. iii, fig. 140 (1870).—*Faxon.* Proc. Amer. Acad. xx, 136 (1884); Revision of Astacidæ, 19, pl. vii, fig. 2, 2′, 2a, 2a′, (1885).

C. acutus, var. B. Hagen, l. c. pl. 36, iii, fig. 144 (1870).

Astacus Blandingii Harlan. Trans. Amer. Philos. Soc. iii, 464 (1830); Med. and Phys. Res. 229, fig. 1 (1835).—?*Le Conte.* Proc. Phila. Acad. vii, 400 (1855).

Hab.—New Jersey, Maryland, Virginia, North Carolina, South Carolina, Georgia.

Var. ACUTA Faxon. Proc. Amer. Acad. xx, 136 (1884); Revision of Astacidæ, 20 (1885).

C. acutus Girard. Proc. Phila. Acad. vi, 91 (1852).—*Hagen.* Monog. Astacidæ, 35, pl. i, figs. 1–5, pl. ii, figs. 106, 108, 110–114, 116, 118, 120–124, 126, 127, pl. iii, fig. 143 (1870).—*Forbes.* Bull. Ill. State Lab. N. H., No. 1, 3, 18 (1876).

C. acutus, var. A. Hagen, l. c. 36, pl. ii, fig. 107, 109, 115, 117, 119, 125 (1870).

C. acutissimus Girard. Proc. Phila. Acad. vi, 91 (1852).

Hab.—Louisiana, Mississippi, Alabama, South Carolina, Tennessee, Missouri, Illinois, Indiana, Iowa, Wisconsin.

10. C. CAROLINUS Hagen (type).—*Faxon.* Proc. Amer. Acad. xx, 140 (1844); Revision of Astacidæ, 54 (1885).

C. advena Hagen. Monog. Astacidæ, 86, pl. i, figs. 90–92 (1870).

Hab.—South Carolina.

11. C. CLARKII Girard, Proc. Phila. Acad. vi, 91 (1852). —*Hagen.* Monog. Astacidæ, 39, pl. i, figs. 7–10, 99, 100, pl. ii, figs. 133, 134, pl. iii, fig. 142, pl. iv (1870).—*Faxon.* Proc. Amer. Acad. xx, 136 (1884); Revision of Astacidæ, 26 (1885).

Hab.—Texas, Louisiana, Mississippi, Alabama, Florida.

12. C. COMPRESSUS Faxon. Proc. Amer. Acad. xx, 127, 146 (1884); Revision of Astacidæ. 105, pl. v, fig. 6, pl. x, figs. 2, 2′, 2a, 2a′ (1885).

Hab.—Alabama.

13. C. CORNUTUS Faxon. Proc. Amer. Acad. xx, 120, 145 (1884); Revision of Astacidæ, 80, pl. v, figs. 1, 2, pl. ix, figs. 3, 3′ (1885).

Hab.—Kentucky.

14. C. DIOGENES Girard. Proc. Phila. Acad. vi, 88 (1852). —*Faxon.* Proc. Amer. Acad. xx, 144 (1884); Revision of Astacidæ, 71 (1885).

C. obesus Hagen. Monog. Astacidæ, 81, pl. i, figs. 39–42, pl. iii, fig. 163, pl. ix (1870).

Hab.—New Jersey, Maryland, District of Columbia, Virginia, North Carolina, Ohio, Indiana, Illinois, Michigan, Wisconsin, Iowa, Missouri, Kansas, Colorado, Wyoming, Arkansas, Kentucky? Mississippi, Louisiana.

15. C. DUBIUS Faxon. Proc. Amer. Acad. xx, 114, 145 (1885); Revision of Astacidæ, 70, pl. iv, fig. 3, pl. viii, figs. 7, 7′ (1885).

Hab.—Virginia, West Virginia, Tennessee.

16. C. EXTRANEUS Hagen. Monog. Astacidæ, 73, pl. i, figs. 88, 89, pl. iii, fig. 156 (1870).—*Faxon.* Proc. Amer. Acad. xx, 145 (1884); Revision of Astacidæ, 84 (1885).

Hab.—Georgia.

17. C. FALLAX Hagen. Monog. Astacidæ, 45, pl. i, figs. 103–105 (1870).—*Faxon.* Proc. Amer. Acad. xx, 136 (1884); Revision of Astacidæ, 23, pl. ii, fig. 4 (1885).

Hab.—Florida.

18. C. FORCEPS *Faxon.* Proc. Amer. Acad. xx, 133, 148 (1884); Revision of Astacidæ, 119, pl. v, fig. 4, pl. ix, figs. 5, 5′, 5a, 5a′ (1885).

Hab.—Alabama, Tennessee?

19. C. GIRARDIANUS Faxon. Proc. Amer. Acad. xx, 117, 145 (1884); Revision of Astacidæ, 78, pl. iv, fig. 1, pl. ix, figs. 2a, 2a′ (1885).

Hab.—Alabama.

20. C. GRACILIS Bundy. Bull. Ill. State Lab. N. H., No. 1, 5 (1876); Trans. Wis. Acad. v, 182 (1882); Geology of Wisconsin, i, 403 (1883).—*Faxon.* Proc. Amer. Acad. xx, 141 (1884); Revision of Astacidæ, 56, pl. viii, figs. 4, 4′, 4″ (1885); Bull. of Washburn Coll. Lab. N. H., i, 140 (1885).

Hab.—Wisconsin, Iowa, Illinois, Kansas.

21. C. HAMULATUS Faxon. Proc. Amer. Acad. xx, 145 (1884); Revision of Astacidæ, 81, pl. iv, fig. 6, pl. ix, figs. 1, 1a′ (1885).

Orconectes hamulatus Cope and Packard. Amer. Nat. xv, 881, pl. vii, figs. 1, 1a, 1b (1881).

Hab.—Nickajack Cave, Tennessee.

22. C. HARRISONII Faxon. Proc. Amer. Acad. xx, 130, 147 (1884); Revision of Astacidæ, 94, pl. iii, fig. 1, pl. ix, figs. 9, 9′ (1885).

Hab.—Missouri.

23. C. HAYI Faxon. Proc. Amer. Acad. xx, 108, 136 (1885); Revision of Astacidæ, 24, pl. i, fig. 4, pl. vii, figs. 3, 3′, 3a, 3a′ (1885).

Hab.—Mississippi.

24. C. IMMUNIS Hagen. Monog. Astacidæ, 71, pl. i, figs. 101, 102, pl. iii, fig. 160, pl. viii, fig. b (1870).—*Smith.* Rep. U. S. Fish Com. for 1872–73, 639.—*Forbes.* Bull. Ill. State Lab. N. H., No. 1, 4, 19 (1876).—*Bundy.* Proc. Phila. Acad. 1877, 171.—*Faxon.* Proc. Amer. Acad. xx, 146 (1884); Revision of Astacidæ, 99, pl. x, figs. 6a, 6a′ (1885).

C. signifer Herrick. 10th Rep. Geol. Minn. 253 (1882).

Hab.—New York, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, Kansas, Wyoming, Alabama, Mexico.

Var. SPINIROSTRIS Faxon. Proc. Amer. Acad. xx, 146 (1884); Revision of Astacidæ, 99, pl. 1, fig. 5 (1885); Bull. Washburn Coll. Lab. N. H., i, 140 (1885).

Hab.—Tennessee, Kansas.

25. C. JORDANI Faxon. Proc. Amer. Acad. xx, 119, 145 (1884); Revision of Astacidæ, 83, pl. iii, fig. 3 (1885).

Hab.—Georgia.

26. C. LANCIFER Hagen. Monog. Astacidæ, 59, pl. i, figs. 86, 87, pl. iii, fig. 159 (1870).—*Faxon.* Proc. Amer. Acad. xx, 146 (1884); Revision of Astacidæ, 86 (1885).

Hab.—Mississippi.

27. C. LATIMANUS Hagen. Monog. Astacidæ, 83, pl. i, figs. 43–46, pl. iii, fig. 162 (1870).—*Faxon.* Proc. Amer. Acad. xx, 144 (1884); Revision of Astacidæ, 69, pl. ii, fig. 3 (1885).

Astacus latimanus Le Conte. Proc. Phila. Acad. vii, 402 (1855).

Hab.—South Carolina, Georgia, Alabama, Mississippi, Tennessee.

28. C. LE CONTEI Hagen. Monog. Astacidæ, 47, pl. i, figs. 15–18, pl. iii, fig. 145 (1870).—*Faxon.* Proc. Amer. Acad. xx, 137 (1884); Revision of Astacidæ, 29, pl. ii, fig. 2 (1885).

Hab.—Georgia, Alabama.

29. C. MANICULATUS Hagen. Monog. Astacidæ, 52 (1870).—*Faxon.* Proc. Amer. Acad. xx, 137 (1884); Revision of Astacidæ, 29 (1885).

Astacus maniculatus Le Conte. Proc. Phila. Acad. vi, 91 (1855).

Hab.—Georgia.

30. C. MEDIUS Faxon. Proc. Amer. Acad. xx, 121, 145 (1884); Revision of Astacidæ, 107, pl. iii, fig. 4, pl. ix, fig. 4, 4′ (1885).

Hab.—Missouri.

31. C. MISSISSIPPIENSIS Faxon. Proc. Amer. Acad. 123, 146 (1884); Revision of Astacidæ, 101, pl. iii, fig. 2, pl. x, figs. 4, 4′, 4a, 4a′ (1885).

Hab.—Mississippi.

32. C. NAIS Faxon. Bull. Washburn Coll. Lab. N. H., i. 140 (1885).

Hab.—Kansas.

33. C. NEBRASCENSIS Girard. Proc. Phila. Acad. vi, 91 (1852).—*Hagen.* Monog. Astacidæ, 83 (1870).—*Faxon.* Proc. Amer. Acad. xx, 145 (1884); Revision of Astacidæ, 75 (1885).

Hab.—Dakota.

34. C. NEGLECTUS Faxon. Bull. Washburn Coll. Lab. N. H., i, 142 (1885).

Hab.—Kansas.

35. C. PALMERI Faxon. Proc. Amer. Acad. 124, 146 (1884): Revision of Astacidæ, 103, pl. iii, fig. 6, pl. x, figs. 5a, 5a′ (1885).

36. C. PELLUCIDUS Girard. Proc. Phila. Acad. vi, 87 (1852).—*Hagen.* Monog. Astacidæ, 55, pl. i, figs. 68–71, pl. iii, fig. 148, pl. vi (1870).—*Faxon.* Proc. Amer. Acad. xx, 139 (1884); Revision of Astacidæ, 40 (1885).

Astacus pellucidus Tellkampf. Arch. Anat. Physiol. u. Wissensch. Med. 1844, 383.

Astacus (Cambarus) pellucidus Erichson. Archiv für Naturgesch., Jahrg. xii, Bd. i, 95 (1846).

Orconectes pellucidus Cope. Amer. Nat. vi, 410, 419 (1872); 3d and 4th Rep. Geol. Indiana, 162, 173 (1872).

Orconectes inermis Cope. Amer. Nat. vi, 410, 419 (1872); 3d and 4th Rep. Geol. Indiana, 162, 173 (1872).

Hab.—Kentucky, Indiana.

37. C. PENICILLATUS Hagen. Monog. Astacidæ, 53, pl. i, figs. 93, 94 [95, 96?] pl. iii, fig. 149 (1870).—*Faxon.* Proc. Amer. Acad. xx, 138 (1884); Revision of Astacidæ, 36 (1885).

Astacus penicillatus Le Conte. Proc. Phila. Acad. vii, 401 (1855).

Hab.—Georgia, Mississippi? South Carolina?

38. C. PROPINQUUS Girard. Proc. Phila. Acad. vi, 88 (1852).—*Hagen.* Monog. Astacidæ, 67, pl. i, figs. 34–38, pl. iii, fig. 153 (1870).—*Faxon.* Proc. Amer. Acad. xx, 147 (1884); Revision of Astacidæ, 91 (1885).

Hab.—Provinces of Ontario and Quebec, New York, Indiana, Illinois, Michigan, Lake Superior, Wisconsin, Iowa.

Var. SANBORNI Faxon. Revision of Astacidæ, 91, pl. v, fig. 3, pl. ix, figs. 10, 10′, 10a, 10a′ (1885).

C. sanborni Faxon. Proc. Amer. Acad. xx, 128, 147 (1884).

Hab.—Kentucky, Ohio.

Var. OBSCURA Faxon. Revision of Astacidæ, 92 (1885).

C. obscurus Hagen. Monog. Astacidæ, 69, pl. i, figs. 72–75, pl. iii, fig. 154 (1870).—*Faxon.* Proc. Amer. Acad. xx, 148 (1884).

Hab.—New York.

39. C. PUBESCENS Faxon. Proc. Amer. Acad. xx, 109, 137 (1884); Revision of Astacidæ. 31, pl. i, fig. 3, pl. viii, fig. 1a, 1a′ (1885).

Hab.—Georgia.

40. C. PUTNAMI Faxon. Proc. Amer. Acad. xx, 131, 148 (1884); Revision of Astacidæ, 118, pl. v. fig. 5, pl. ix. figs. 6, 6′, 6a, 6a′ (1885).

Hab.—Kentucky, Tennessee, Indiana?

41. C. RUSTICUS Girard. Proc. Phila. Acad. vi, 88 (1852). —*Hagen.* Monog. Astacidæ, 71, pl. i, figs. 80–83, pl. iii, fig. 161 (1870).—*Faxon.* Proc. Amer. Acad. xx, 148 (1884); Revision of Astacidæ, 108, pl. ix, figs. 8, 8′, 8a, 8a′ (1885).

C. placidus Hagen. l. c. 65, pl. i, figs. 76–79, pl. iii, fig. 158 (1870).

C. juvenilis Hagen. l. c. 66, pl. i, figs. 29–33, pl. iii, fig. 157 (1870).

C. wisconsinensis Bundy. Bull. Ill. State Lab. N. H., No. 1, 4 (1876); Trans. Wisconsin Acad. v, 181 (1882); Geol. Wisconsin, i, 402 (1883).

Hab.—Pennsylvania, Ohio, Indiana, Illinois, Kentucky, Tennessee, Wisconsin, Iowa, Missouri, Texas, Lake Superior.

42. C. SHUFELDTII Faxon. Proc. Amer. Acad. xx, 134, 149 (1884); Revision of Astacidæ, 124, pl. vii, fig. 1, pl. x, figs. 8, 8′, 8a, 8a′ (1885).

Hab.—Louisiana.

43. C. SIMULANS Faxon. Proc. Amer. Acad. xx, 112, 140 (1884); Revision of Astacidæ, 48, pl. i, fig. 12, pl. viii, fig. 3, 3′, 3a, 3a′ (1885).

Hab.—Texas, Kansas.

44. C. SLOANII Bundy. Bull. Ill. State Lab. N. H., No. 1, 24 (1876); Proc. Phila. Acad. 1877, 172.—*Faxon.* Proc. Amer. Acad. xx, 147 (1884); Revision of Astacidæ, 86, pl. iv, fig. 5, pl. x, figs. 1, 1′, 1a, 1a′ (1885).

Hab.—Indiana, Kentucky.

45. C. SPICULIFER Hagen. Monog. Astacidæ, 48, pl. i. figs. 59–62, pl. iii, fig. 147 (1870).—*Faxon.* Proc. Amer. Acad. xx. 138 (1884); Revision of Astacidæ, 33, pl. ii, fig. 5 (1885).

Astacus spiculifer Le Conte. Proc. Phila. Acad. vii, 401 (1855).

Hab.—Georgia.

46. C. SPINOSUS Bundy. Proc. Phila. Acad. 1877, 173.—*Faxon.* Proc. Amer. Acad. xx, 148 (1884); Revision of Astacidæ, 115, pl. ix, figs. 7, 7′, 7a, 7a′ (1885).

Hab.—South Carolina, Georgia, Alabama.

* C. STYGIUS Bundy. Bull. Ill. State Lab. N. H., No. 1, 3 (1876); Trans. Wisconsin Acad. v, 180 (1882); Geology of Wisconsin, i, 402 (1883).—*Faxon.* Proc. Amer. Acad. xx, 140 (1874); Revision of Astacidæ, 56 (1885).

* C. TYPHLOBIUS Faxon. Revision of Astacidæ, 45 (1885).

C. stygius Joseph. Berliner Entom. Zeitschr. xxvi (1882).

47. C. TROGLODYTES Hagen. Monog. Astacidæ, 41, pl. i, figs. 11–14, pl. ii, fig. 141 (1870).—*Faxon.* Proc. Amer. Acad. xx, 136 (1884); Revision of Astacidæ 27 (1885).

Astacus troglodytes Le Conte. Proc. Phila. Acad. vii, 400 (1855).

A. fossarum Le Conte, l. c. 401 (1855).

Hab.—Georgia, South Carolina.

48. C. UHLERI Faxon. Proc. Amer. Acad. xx, 116, 145 (1884); Revision of Astacidæ, 77, pl. viii, figs. 8, 8′, 8a, 8a (1885).

Hab.—Maryland.

49. C. VERSUTUS Hagen. Monog. Astacidæ, 51, pl. i, figs. 55–58, pl. iii, fig. 150 (1870).—*Faxon.* Proc. Amer. Acad. xx, 138 (1884); Revision of Astacidæ, 34 (1885).

Hab.—Florida, Alabama.

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* These species are doubtful, and hence excluded from the numbered list, in accordance with Faxon's revision.

50. C. VIRILIS Hagen. Monog. Astacidæ. 63, pl. i, figs. 23–28, pl. ii, figs. 128–132, pl. iii, fig. 155, pl. viii (1870).—*Herrick.* 10th Rep. Geol. Minn. 253 (1882).—*Faxon.* Proc. Amer. Acad. 147 (1884); Revision of Astacidæ, 96 (1885).

C. debilis Bundy. Bull. Ill. State Lab. N. H., No. 1, 24 (1876); Trans. Wisconsin Acad. v, 181 (1882); Geology of Wisconsin, i, 403 (1883).

C. couesi Streets. Bull. U. S. Geol. Survey (Hayden), iii, 803 (1877).

Hab.—Canada, Dakota, Minnesota, Wisconsin, Iowa, Nebraska, Wyoming, Kansas, Missouri, Illinois, Indiana, Tennessee, Texas, New York?

FAMILY PALÆMONIDÆ.

I. PALÆMON FABR., STIMPSON.

1. P. OHIONIS Smith. Rep. U. S. Fish Com. for 1872–73, 640.—*Forbes.* Bull. Ill. State Lab. N. H., No. 1, 5 (1876).—*Hay.* Amer. Nat. xvi, 143 (1882).

Hab.—Indiana, Illinois, Mississippi, Mississippi River.

II. PALÆMONETES HELLER.

1. P. PALUDOSA Kingsley. Proc. Phila. Acad. 1878, 97; Bull. Essex Inst. x, 65.

P. exilipes Stimpson. Ann. N. Y. Lyceum N. H., x, 130 (1871).—*Smith.* Rep. U. S. Fish Com. for 1872–73, 641.—*Forbes.* Bull. Ill. State Lab. N. H., No. 1, 5 (1876).—*Hay.* Amer. Nat. xvi, 144 (1882).

Hippolyte paludosa Gibbes. Proc. A. A. A. S., iii, 197 (1850).

Hab.—Ohio, Illinois, Michigan, Tennessee, South Carolina, Florida, Mississippi.

FAMILY PENÆIDÆ.

I. PENÆUS LATR.

1. P. BRAZILIENSIS Latr. Nouv. Dict. d'Hist. Nat., 154, t. xxv.—*Milne-Edwards.* Hist. Nat. des Crust. ii, 414 (1837).—*Stimpson.* Ann. N. Y. Lyceum N. H., x, 132 (1871).—*Smith.* Rep. U. S. Fish Com. for 1872–73, 642.

Hab.—New York, New Jersey.

II. BIBLIOGRAPHY.

The following papers, which include the principal works relating to the Fresh Water Crustacea in general, contain references to species known to inhabit North America. It will be seen to include numerous papers by Americans from Say's time to the present.

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———Monograph of the Family Limniadæ, a Family of Entomostracous Crustacea. Proceedings of the Zoölogical Society of London, xvii, 84–90, (1849).

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INDEX OF GENERA.

(Families in Small Capitals, orders in CAPITALS.)

ARTICLE VI.—*Parasitic Fungi of Illinois.* PART II. By T. J. BURRILL and F. S. EARLE.

ERYSIPHEÆ, LÉV.

(Ann. Sci. Nat., Ser. III., Tome XV.)

On living plants. Mycelium superficial, consisting of numerous branching, septate, usually white, much interwoven threads, which extend widely over the epidermis of the host, adhering to it by means of haustoria; conidia simple, colorless, cylindrical, oval or ovate, borne one above the other. on erect, simple, septate colorless hyphæ; perithecia seated singly on the mycelium, membranaceous, indehiscent, globose or sometimes depressed, at first colorless, then yellow, becoming dark brown or black when mature, bearing various thread-like appendages; asci arising from the base of the perithecium, delicate, thin-walled, colorless, oblong, oval, ovate or suborbicular, usually pedicellate, containing 2–8 spores; spores (except in *Saccardia*) simple. colorless, granular, oblong or oval.

The *Erysipheæ*, commonly known as "white mildews" or "blights," may be easily recognized by the white, dusty or web-like coating they form on the leaves, or other succulent parts, of many common plants. They frequently grow throughout the summer, but, usually, only reach their full development in the fall, when the perithecia, or little fruit-balls, may be seen like minute black or dark brown dots scattered over the whitened surface of the leaves.

The very abundant mycelium consists of numerous slender, white or colorless, septate threads, that branch widely, and extend over the leaf in every direction, frequently crossing and interlacing. These threads are usually pressed close to the host, but they do not themselves enter it.* They send out at intervals, however, short special branches called haustoria, that

* It is held by some writers that in *Sphærotheca pannosa*, Lév., the mycelium does sometimes enter the tissues of the host, but this is not satisfactorily proven.

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penetrate the epidermal cells, serving for the secure attachment of the fungus, and probably also for its nourishment. These haustoria present several forms, and they are of some importance in the classification of the species. In some cases the haustorium simply consists of a slender tube which penetrates the epidermal cell of the host, within which it swells to an oval or club-shaped sac, filled with granular protoplasm. More often there is an external appendage or sucker, that is pressed close to the surface of the epidermal cell; and from this, or from near it on the mycelial thread, the haustorium proper takes its rise and penetrates the epidermis. This external appendage may be smooth and entire, merely constituting a hemispherical swelling on the mycelial thread; or, it may take the form of a flattened disk with an indented margin. In the latter case they are said to be "lobed," in the former, "not lobed."

The conidia, or asexual reproductive bodies, are cylindrical, oval or nearly orbicular, simple, colorless cells filled with protoplasm. They are formed by constriction at the ends of short, simple, erect, rather stout, septate, colorless branches of the mycelium, called fertile hyphæ or conidiophores. A septum forms near the end of the young hypha, and the walls at this point become constricted. The cell thus cut off usually swells a little, and at length falls away as a mature conidium. Before this happens, however, other constrictions have taken place below, thus forming a chain of nearly mature conidia adhering end to end. Under favorable conditions they germinate quickly, sending out a slender tube, which, on the proper host, soon develops into a new mycelium. They are produced in immense numbers throughout the growing season, and, as they are very light and easily carried by the wind, they serve for the rapid increase and wide distribution of the parasite.

Other reproductive bodies arise, like the fruits of higher plants, from a process of fertilization. The process has been carefully studied by De Bary and others. It differs slightly in the different genera. In those with a single ascus (*Sphærotheca* and *Podosphæra*) it is as follows:—

Where two threads of the mycelium approach or cross each other, a short special branch arises from each. One of

these swells to two or three times the diameter of the thread, and is separated from it by a transverse partition. It now constitutes the carpogonium, homologous with the pistil of the flowering plants. The other branch, the antheridium, remains cylindrical, and is closely applied to the carpogonium, bending over its summit. A septum is formed near the tip, dividing off a small cell, whose contents, passing into the carpogonium, effect its fertilization. Slender branches now arise on all sides from near the base of the carpogonium. They become branched and septate, and soon join together, forming a membranous, cellular, enveloping wall. An inner membrane or coating is developed by short projections branching from the inner wall. The carpogonium is divided by a cross partition, and the upper portion develops into the suborbicular ascus containing the spores, which with its enveloping membranes constitutes the sporocarp, or true fruit of the fungus. In the genera having several asci the carpogonium is more elongated, and is bent around the antheridium. After fertilization, the enveloping wall develops as above. The carpogonium becomes divided by cross partitions into a number of cells, each of which either develops directly into an ascus, or sends up an ascus-bearing branch. In all cases the spores develop within the asci by free cell-formation.

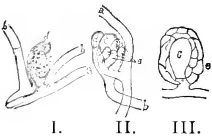

FIG. 1.

FIGURE 1. *Sphærotheca Castagnei*, Lév. I., Process of fertilization: *a*, a thread of the mycelium bearing the oögonium *c*; *b*, *b*, another filament of the mycelium bearing the antheridium *d*. II., same as I., at a later stage of growth, the oögonium *c* and antheridium *d* still seen, the former becoming inclosed by the mycelial branches *e*. III., a still later stage of same, the oögonium *c* being now completely inclosed within the tissue forming the mycelial branches, the wall of the young carpogonium. Magnified 300 times. (After De Bary.)

This act of fertilization does not usually take place till late in the summer. The sporocarp resulting from it is called in this group, the perithecium. When quite young it is colorless, but it soon becomes yellowish, and when mature is a dark brown or black, usually globular, body, visible to the naked eye. Its wall consists of a rather tough membrane, whose cellular struc-

ture can be seen in the more or less distinct reticulations of its surface. It is provided with slender hair-like outgrowths called appendages, very characteristic of this family. These present many forms, and it is from them that the generic characters are mostly taken. The perithecium remains on the fallen leaves over winter. It is not provided with a mouth or ostiolum of any kind. The contained asci and spores only escape on its decay in the spring.

The asci are delicate, thin-walled, colorless sacs filled with granular protoplasm, from which the spores are formed. The latter (except in *Saccardia*) are simple, colorless, oblong or oval cells, filled with densely granular protoplasm. In the genus *Saccardia*, occurring on oak leaves in the Southern States, the spores are septate or "muriform," and colored.

Delicate membranaceous conceptacles, other than the perithecia, are sometimes found in connection with the mycelium of the *Erysipheæ*. They are thin-walled, and on slight pressure rupture irregularly, emitting immense numbers of minute oblong nucleated spores, immersed in a gelatinous fluid. They were noticed by Cesati, in connection with the grape milde w Supposing them to be independent organisms, he named them *Ampelomyces quisqualis*, and specimens were published under that name as No. 1669 in Rabenhorst's Herbarium Mycologicum. Later they were called *Cicinobolus florentinus* by Ehrenberg, and *Byssocystis textilis* by Riess. Tulasne, von Mohl, and others, finding that these conceptacles were borne on the same mycelium as the conidia and perithecia, naturally concluded that they were organs of the same plant, and, from their analogy to certain asexual reproductive bodies in allied groups of the *Ascomycetes,* called them pycnidia, and the minute bodies they contain stylospores or pycnidiospores. This is still the accepted belief of many botanists. De Bary (Morph. und Phys. der Pilze, III., pp. 53–75, Tafeln VI., VII.) shows that the pycnidia instead of being reproductive organs of the *Erysiphe,* are, in reality, the fructification of a fungus that is parasitic on the *Erysiphe.* He calls it *Cicinobolus Cesatii*, and gives numerous figures showing its delicate septate mycelium developing within the mycelial threads of the *Erysiphe*, and sending up branches which, by repeated division, form the cellular wall of the pycnidium.

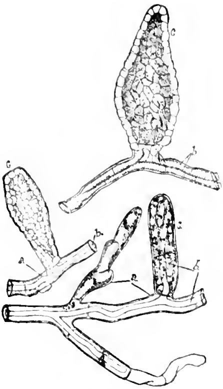

Fig. 2.

FIGURE 2. *Cicinobolus Cessatii*, DBy.: *a* the mycelium of *Erysiphe galeopsidis*, DC., within which is to be seen the parasitic mycelium *b* of *Cicinoblus*; *c*, *c*, *c* different stages of the so-called pycnidium in which the spores of the parasite are developed. Magnified 300 times. (After De Bary.)

This frequently develops in one of the cells of a conidiophore, in which case the shriveled upper portion remains as a kind of appendage. In other cases it is developed directly from the mycelium. Occasionally, on rupturing a perithecium, it will be found to contain minute bodies like *Cicinobolus* spores, instead of asci. This is considered a fourth kind of reproductive body by Berkeley (Introduction to Crypt. Bot. p. 78). It is more likely a case of the *Cicinobolus* developing its fruit within the growing perithecium.

This parasite has been mostly investigated in connection with the grape mildew *(Erysiphe Tuckeri)*. Some writers suppose it to be of considerable use in holding this disease in check (Thümen, Pilze des Weinstocks, p. 178). It occurs on several of our specimens of *Erysiphe cichoracearum*, DC., where its delicate mycelium can be seen by the aid of a good objective and careful manipulation.

Various *Macrosporium*- and *Helminthosporium*- like bodies are frequently associated with *Erysiphe* mycelium, but their organic connection with it is doubtful. Minute yellow spherical echinulate bodies are also often seen clinging to it, but they are foreign substances,— probably pollen grains.

The abundant mycelium of these plants is so conspicuous that it early attracted the attention of investigators. The

literature of the family is unusually large and extended; and arising from so many independent sources, and representing such widely different views, there is so much confusion of names and descriptions that the difficulty of study is increased rather than lessened by its abundance. The plants form a natural, closely related, and easily recognized group; but its rank and position in the natural system has been very differently estimated by different writers.

They were known to Linnæus under the common name of *Mucor erysiphe.* Persoon (Syn. Fung., p. 124) called them all *Sclerotium erysiphe*, but separated as a variety the form on *Corylus*, now classed in the genus *Phyllactinia.* Soon writers began to distinguish different species, but referred them all to a single genus called *Erysibe* by Link and Rabenhorst, *Alphitomorpha* by Wallroth and Schlectendal, and *Erysiphe* by Hedwig, the latter followed by De Candolle, Schweinitz, Fries, and others. This genus was often classed among the puff-balls, (*Gasteromycetes*). In 1851 Léveillé published a monograph of the group (Ann. Sci. Nat., Ser. III., Tome XV.) in which he divided the old genus *Erysiphe* into six genera as follows:—

Sphæroetheca.— Perithecium containing a single ascus, appendages floccose, undivided.

Podosphæra. — Perithecium containing a single ascus, appendages dichotomously divided at the tip.

Uncinula.—Asci several, appendages coiled at the tip.

Phyllactinia.— Asci several, appendages straight, rigid, swollen at base.

Microsphæra.— Asci several, appendages dichotomously divided.

Erysiphe.—Asci several, appendages floccose, undivided.

Tulasne (Select. Fung. Carp. Vol. I., [1861]) does not adopt this division, but returns all the species to the genus *Erysiphe.* De Bary (Morph. und Phys. der Pilze III. [1870]) divides the group into two genera according to the characters of the carpogonuim, calling those *Podosphæra* in which this organ is straight (orthotropus) and which develop only one ascus, and retaining the name *Erysiphe* for those with a curved (campylotropus) carpogonium and several asci. For a true,

natural classification, the life history of plants must be taken into account, no matter how obscure and impractical, for ordinary work, the characteristics it affords may be. It is probable that De Bary's arrangement is more logical; but for convenience most modern botanists use Léveillé's classification, which is the one adopted in this paper.

The true position and rank of the group in the vegetable kingdom still seems to be a matter of doubt, no two authors exactly agreeing in regard to it. The arrangement adopted by Winter (Die Pilze, II.) perhaps on the whole best expresses their true relations. It is essentially the same as that proposed by Saccardo (Sylloge Fung., I.) and may be expressed as follows:—

Class........................*Ascomycetes.*
Order..........................*Pyrenomycetes.*
Suborder........................*Perisporiaceæ.*
Family.............................*Erysipheæ.*

It is usually easy to determine, even without the aid of a magnifier, whether or not a given fungus belongs to this family; and a moment's examination of the mature perithecium under the microscope will suffice to place it in its proper genus. Specific determination is often a matter of much greater difficulty. In other groups of parasitic fungi, as, for instance, the *Uredineæ*, the species are, for the most part, confined quite closely to a single host, or at least to a few very closely related host species. Very slight differences in the form or markings of the spores, taken in connection with a difference of host plant, are considered of specific importance. Some of the *Erysipheæ* have long been recognized as having a much wider range of habitat; but it was natural for the botanist, if he found a plant of this family developing on a new host, to consider it a new species, especially if he observed a few more or a few less asci or spores, or found the appendages differing in number or length from the descriptions of other accepted species. Then, too, owing to the poor instruments at their command, the descriptions of the earlier investigators are lacking in those microscopical characteristics that are now so carefully noted. While the above view of narrow specific

limitations prevailed, the older names were apt to be disregarded By further study, and the comparison of numerous specimens of each of the so-called species, it becomes apparent that in very many cases the differences between them in the number and length of the appendages, the number and size of the asci and spores, and the appearance of the mycelium,— all so easily recognized in single instances,— are not constant; that these parts are exceedingly variable, and that it is frequently impossible to maintain distinctions based on them. This necessitates the putting together of forms often considered specifically distinct, and a corresponding change in specific descriptions.

This wider view of the limits of species sometimes throws new light on the work of the earlier mycologists, enabling us to decide with reasonable certainty whether or not their names should be adopted for the species as now understood. The process leads to the abandonment of some familiar names, which is always to be regretted; but the true interests of a stable nomenclature demand the adoption of the earliest specific name given to any form of the species. (See Bull. Ill. State Lab. Nat. Hist., Vol. II., p. 149.)

In his admirable revision of the fungi for "Rabenhorst's Kryptogamic Flora," Winter has very carefully and thoroughly performed this labor for the European species of *Erysipheæ*, and his nomenclature is adopted, for the most part, in this paper, for those species common to both continents, such changes only being made as are suggested by the study of numerous American specimens. The distinctively American species are usually much less encumbered with synonyms than those that also occur in Europe. In a number of cases, however, names have been given to forms that cannot now be considered distinct, and, in some cases, owing to the difficulty of interpreting his descriptions, the names given by Schweinitz have been disregarded. The attempt is here made to clear up these difficulties, so far at least as our Illinois species are concerned.

Some of the species of *Erysipheæ* are of practical interest from the injuries they do to cultivated plants. The mildew of

roses, hops, gooseberries, raspberries, grapes,* and of many ornamental plants and trees, is caused by different species of this family. As their development is superficial, they are easily reached by remedial agents. Sulphur has long been successfully used to check the ravages of the grape mildew, and as a remedy for rose mildew in greenhouses. Its use is often indiscriminately recommended for any and all of these diseases, but the caution should be added, that, in some cases, the host plant suffers more from the sulphur, as usually applied, than from the parasite. The fact is, that each case needs careful practical study before a remedy can be safely recommended. More recently sulphate of copper has come into extended use for the destruction of various fungous parasites. The crystals may be dissolved in water — one pound to two gallons — and used as a spray. Or the mixture may be improved by the addition of lime slacked in water, — the whole so diluted that it can be easily applied with a broom or whisk. As the copper sulphate is poisonous, care must be exercised in handling and applying. The remedy appears to be serviceable against the *Peronospora* of the vine as well as for the special fungi to which attention is herein directed.

Illustrations of the Genera.

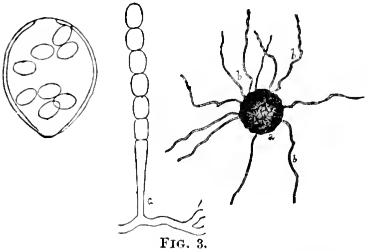

Fig. 3.

Figure 3. *Sphærotheca Castagnei*, Lév.: *a*, perithecium with *b* appendages,— magnified 90 times; *c*, fertile hypha or conidiophore, bearing six conidia which readily separate at the constrictions,— magnified 190 times; *d*, the single ascus with eight spores,— magnified 250 times.

* The commonest "grape mildew" in this country is caused by a very different fungus, *Peronospora viticola*, B.&C.

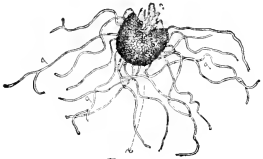

FIG. 4.

FIGURE 4. *Erysiphe chicoracearum*, DC. A ruptured perithecium with thread-like appendages and protruding asci, each containing two spores, — magnified 90 times.

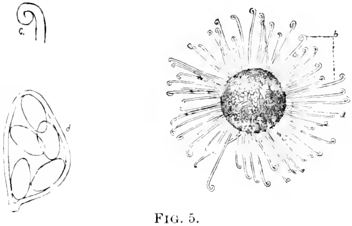

FIG. 5.

FIGURE 5. *Uncinula ampelopsidis*, Peck: *a*, perithecium with the numerous appendages (*b*) coiled at the tip,— magnified 100 times; *c*, one of the appendages (tip) further magnified; *d*, an ascus with five spores,—magnified 200 times. The lower, pointed end of the ascus is attached to the bottom of the cavity of the perithecium.

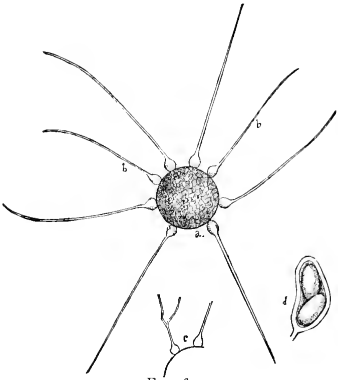

FIG. 6.

FIGURE 6. *Phyllactinia suffulta*, (Reb.) Sacc.: *a*, perithecium with the needle-shaped appendages (*b*) swollen at base,—magnified 50 times; *c*, a branched appendage; *d*, an ascus with two spores,— magnified 100 times. The point (pedicel) of attachment is shown. The appendages are normally quite straight, but are here shown as they appeared under the microscope, possibly mechanically bent.

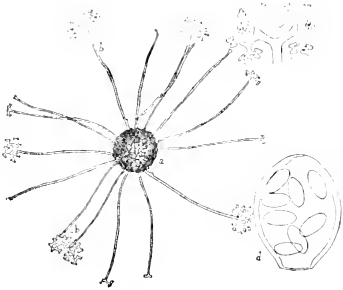

FIG. 7.

FIGURE 7. *Podosphæra oxycantha*, (DC.) DBy.: *a*, pericthecium with dichotomously forked appendages *b*,—magnified 90 times; *c*, a tip of an appendage more magnified; *b*, the single ascus with eight spores,—magnified 325 times.

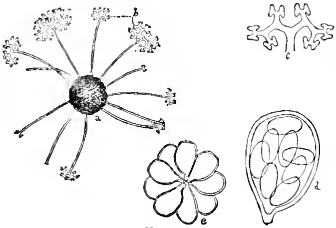

FIG. 8.

FIGURE 8. *Microsphæra Ravenelii*, Berk.: *a*, perithecium with its dichotomously forked appendages *b*,—magnified 75 times; *c*, a tip of an appendage more magnified; *d*, one of the several asci containing eight spores,—magnified 375 times; *e*, a group of asci from one perithecium,—magnified 150 times.

KEY TO THE GENERA OF ERYSIPHEÆ.

I. Appendages consisting of simple threads similar to the mycelium, and often interwoven with it............A.

II. Appendages dissimilar to, and free from the mycelium.B.

A. Perithecia containing only one ascus..SPHÆROTHECA.
   Perithecia containing several asci.........ERYSIPHE.

B. Appendages simple, not usually forked at the tip...1.
   Appendages dichotomously forked at the tip.......2.

1. Appendages coiled at the tip, asci several.
   UNCINULA.
   Appendages needle-shaped, abruptly swollen at base, asci several.............PHYLLACTINIA.

2. Perithecia containing only one ascus.
   PODOSPHÆRA.
   Perithecia containing several asci.MICROSPHÆRA.

Note. Three other genera have been described as follows:—

(1). *Pleochæta* (Saccardo, Sylloge Fungorum, I., p. 9). Perithecia globose-lenticular, indehiscent, texture subcoriaceous, parenchymatous; appendages very numerous, rod-like, straight, simple, hyaline; asci clavate, two-spored; spores simple, elliptical, subhyaline. *P. Curtisii*, Sacc. & Speg. occurs on leaves of *Celtis* in Alabama and Carolina, and in South America.

(2). *Erysiphella* (Peck, 28th Report, New York State Museum p. 63). "Perithecia destitute of appendages, spores definite." *E. aggregata*, Peck, is described on the fertile aments of *Alnus serrulata*.

(3). *Saccardia* (Cooke, Grevillea VII. [1878], p. 49). Mycelium arachnoid, often evanescent; perithecia globose, asci globose-ovate, 8-spored; spores elliptical, many-celled; appendages none or interwoven with the mycelium. *S. quercina*, Cooke on the leaves of *Quercus virens*, Georgia, and *S. Martii*, Ell. & Sacc. on *Q. laurifolia*, Florida, have been described. None of these plants are known in Illinois. Doubts may be expressed as to the validity of these groups as genera of *Erysipheæ*.

Calocladia, Lév. is a synonym for *Microsphæra*, but was previously used for a genus of *Algæ*.

Erysibe was used for *Erysiphe* by several authors, and Wallroth's genus *Alphitomorpha* was made to include all of the *Erysipheæ*.

SPHÆROTHECA, Lév.

(Ann. Sci. Nat., Series III., Tome XV., p. 138.)

Perithecium containing only one ascus. Appendages simple threads not unlike the mycelium with which they are frequently interwoven. Ascus suborbicular, usually containing eight spores. Very rarely two asci have been observed.

S. pannosa, (Wallr.) Lév.

(l. c. p. 138.)

Alphitomorpha pannosa, Wallr. (Verhand. d. Naturf. Freunde, I., p. 43).

Erysibe pannosa, Lk. (Species Plant. VI., I., p. 104).

Eurotium rosarum, Grev. (Scott. Crypt. Fl. III., p. 164, Fig. 2).

Mycelium abundant on the leaves, stems, etc., often sterile; perithecia more often occurring on the branches, scattered, delicate, 90–100 μ, reticulations evident, small, 10–15 μ; appendages short and delicate, much interwoven with the mycelium, sometimes colored; ascus large, delicate, ovate, expanding, when free from the perithecium, to a length greater than its diameter; spores 8, large, 29 μ long.

On *Rosa* sps.: Cook, Sept. 7, 1458; McHenry, Aug. 20, 1212; Pulaski, May 5, 4537. *Rose* stems: Champaign, autumn (Burrill). *Rosa lucida:* Union, Aug. 20 (Earle).

Winter (Die Pilze, II., p. 26) and Saccardo (Syl. Fung. I., p. 2) describe this species with hyaline appendages; but Tulasne (Fung. Carp. Select. I., p. 208) describes them as colored. They frequently are colored in our specimens. De Bary (Morph. und Phys. der Pilze, II., p. 48) says "colorless or brown at base."

S. mors-uvæ, (Schw.) B. & C.

(Grev. IV., p. 158.)

Erysiphe mors-uvæ, Schw. (N. A. Fungi, p. 270).

Mycelium abundant, at first white, becoming dark brown, densely covering the leaves, stems, and fruit; perithecia most abundant on the stems and fruit, densely aggregated, embedded in the thick felted mycelium, variable in size, 90–120 μ, dark brown, reticulations obscure; appendages short, delicate, hyaline or slightly colored, interwoven with and overrun by the dense mycelium; ascus broadly elliptic, eight-spored, both ascus and spores smaller than in *S. pannosa*.

On *Ribes rotundifolium:* McLean, July 16, 2373; La Salle, June 16, 5216. *Ribes* (cultivated): Pulaski, May 8, 4572; Union, June 22 (Earle).

This is the common "gooseberry mildew." It has been referred to *S. pannosa* (Bessey, Erysiphei, p. 3, etc.), but it is sufficiently distinguished by its dense, dark-colored mycelium, which is strikingly unlike that of most of the *Erysipheæ*.

S. pruinosa, C. & P.

(Erysiphei of the U. S.)

Hypogenous; mycelium thin, effuse, persistent; conceptacles minute, black; appendages few, long, colorless, sporangium, ovate, eight-spored.

Leaves of *Rhus glabra*. Greenbush, August.

The long colorless appendages readily distinguish the species from the preceding [*S. Castagnei*, Lév.]. The whole surface of the leaf appears pruinose.—Peck, 25th Rep. N. Y. State Mus., p. 94.

On *Rhus copallina:* Union, Sept. 17 (Earle).

Our specimen is not sufficient for full identification, but it is doubtless the same as that described above by Peck.

S. humuli, (DC) Burrill.

Erysiphe humuli, DC. (Flore Franc., VI., p. 106.
Sphærotheca Castagnei, Lév., in part.

Mostly hypophyllous. Myceliumin conspicuous or evanescent; perithecia scattered, abundant, mostly rather small, 75–95μ, wall-texture firm and compact though thin, surface smooth, reticulations small, often obscure, usually less than 15 μ; appendages slender, three or more times as long as the diameter of the perithecium, colored throughout when mature, mostly free from the mycelium; ascus broadly elliptical or suborbicular; spores usually 8, large, averaging 20 μ long.

On *Agrimonia Eupatoria:* McHenry, Aug. 20, 1183, 1213, Aug. 23, 1249, 1267; McLean, July 2, 2369; Ogle, Sept. 22, 6106 (with coleosporium): Adams, July 10 (Seymour).

This form on *Agrimonia* has usually been referred to *Sphærotheca Castagnei*, Lév. (Rabh, Fungi Europ. No. 558; Winter, Die Pilze, II., p. 27; Saccardo, Syl. Fung., I., p. 4; Trelease, Parasitic Fung. of Wis., p. 9; Peck, 29th Rep. N. Y. State Mus., p. 79). A careful examination of American and European specimens on this host and on *Potentilla*, show marked differences between them and the typical form of *S. Catagnei* on various *Compositæ*, etc. They agree, however, with the European form on *Humulus* (Rabh. Fung. Europ. No. 1049 b). Tulasne (Fung. Carp. Select. I., Tab. IV., 9), under the name of *Erysiphe humuli*, DC. gives an accurate figure of this form, showing the long, slender, colored appendages and the compact small-celled wall of the perithecium. It seems best, therefore, to revive De Candolle's old species and refer to it the forms on *Humulus*, *Agrimonia*, and *Potentilla*. The perithecia closely resemble those of *S. pannosa*, but it differs in the larger appendages and the much less abundant mycelium.

S. Castagnei, Lév.

(Ann. Sci. Nat., Ser. III., Tome XV., p. 139.)

Mycelium abundant and persistent or sometimes inconspicuous, occurring on either or both sides of leaves; perithecia abundant, scattered or somewhat aggregated, small, usually about 75 μ, but varying from 60–100 μ; texture soft, surface uneven, reticulations very large and irregular, 20–30 μ; append-

ages long, stout, usually colored throughout, flexuous, somewhat uneven in width, more or less interwoven with the mycelium; ascus rather small, elliptical or suborbicular; spores usually 8, small, about 15 μ long.

On *Bidens frondosa:* Jo Daviess, Sept 15, 5904; Stephenson, Sept. 13, 5842; Lee, Sept. 9, 5743; McLean, July 2, 2370; La Salle, Sept. 12, 1489, Sept. 16, 1554; Henry, Sept. 28, 1708; McHenry, Aug. 20, 1168; Union, Sept. 13 (Earle). *Bidens connatus:* Rock Island, Sept. 24, 1624; Fulton, Oct. 1, 1777. *Erechthites hieracifolia:* McHenry, Aug. 23, 1234; Champaign, Sept. 19, 6615; Adams, Aug. 20 (Seymour). *Nabalus* sps.: McLean, Sept. 20, 5662; Jo Daviess, Sept. 16, 5945. *Taraxicum dens leonis:* Champaign, Oct. 16, 6580, Oct. 23, 6590. *Veronica Virginica:* McHenry, Aug. 27, 1333; Stephenson, Sept. 13, 5809, Sept. 14, 5878; Jo Daviess, Sept. 15, 5906, Sept. 18, 5975, Sept. 19, 6002, Sept. 20, 6017; Ogle, Sept. 23, 6134. *Gerardia grandiflora:* Ogle, Sept. 23, 6129. *Brunella vulgaris:* McLean, July 3 (Seymour); Champaign, Oct. (Waite).

This abundant and widespread species can be easily distinguished from the form on *Rosaceæ*, etc., that has usually been associated with it, by the peculiarly low and large-celled, wall of the perithecium, and by the larger, more flexuous appendages. The spores, too, average smaller. It varies considerably on the different hosts, in the appearance of the mycelium and the size of the perithecia, these being larger than the average on *Erechthites* and usually smaller on *Veronica;* but the more important characteristics appear to be constant.

ERYSIPHE, (Hedw.) LÉV.

(Ann. Sci. Nat., Ser. III., Tome. XV.)

Perithecium containing several asci; appendages simple threads similar to and frequently interwoven with the mycelium.

E. liriodendri, Schw.

(N. A. Fungi, p. 269.)

On leaves and succulent stems. Mycelium abundant, dense, white, persistent; perithecia developing late, mostly after the

leaves have fallen, rather large, 100 μ or more, delicate, thin-walled, embedded in and partially covered by the dense mycelium, reticulations small and indistinct; appendages several, hyaline, rather long, much interwoven with the mycelium; asci several, eight or more; spores 6—8, small.

On *Liriodendron tulipifera:* Union, Oct. 29, 2106, 2110; Champaign, (Burrill). Schweinitz describes the peculiarly dense and felted white mycelium of this species. Peck (30th Rep. N. Y. State, Mus., p. 58) mentions it as occurring at Oneida, N. Y., but gives no description. Saccardo (Syl. Fung., I., p. 21) mentions it among "*species inquirendæ.*" A full description is published here for the first time. It is not uncommon in Illinois but can seldom be collected in good condition.

E. communis, (Wallr.) Fr.
(Summa. Veg. Scand., p. 406.)

Alphitomorpha communis, horridula, Wallr., in part, (Verhdl. Naturf. Freunde, I).
Erysibe communis, nitida, horridula, Rabh. (Deutschl. Crypt. Flora).
Erysibe communis, Lk., in part.
Erysiphe aquilegiæ, DC. (Flore Franc., VI., p. 105).
Erysiphe pisi, DC. (l. c., VI., p. 274).
Erysiphe convolvuli, DC. (l. c., II., p. 274).
Erysiphe polygoni, DC. (l. c., II., p. 273).
Erysiphe communis, Fr. (Summa. Veg. Scand., p. 406).
Erysiphe communis, Martii, Lév., in part, (Ann. Sci. Nat., Ser. III., Tome XV).

Amphigenous. Mycelium abundant, persistent or sometimes evanescent; perithecia variable in size and reticulations; appendages variable in length, often quite long, lying on the mycelium or more or less interwoven with it, usually colored in part or throughout, but occasionally all hyaline; asci 4–8, or more; spores mostly 4–8, variable in size.

On *Clematis* sps.: Union, Aug. 30 (Earle). *Thalictrum purpurascens:* Jo Daviess, Sept. 18, 5977. *Ranunculus abortivus:* McLean, July 16, 2365, Aug. 1, 2367; Jo Daviess, Sept. 15, 5905; Sept. 30, 6040; Champaign, Oct. 23, 6596; Nov. 3, 6609; La Salle, Sept. 30, 6257. *Geranium maculatum:* La Salle, Sept. 30,

6248. *Pisum sativum:* Champaign, Oct. 19 (Burrill). *Astragalus Canadensis:* Jo Daviess, Sept. 15, 5907; Stephenson, Sept. 21, 6074. *Amphicarpæa monoica:* La Salle, Sept. 12, 1473, 1482; Henry, Sept. 28, 1719; Jo Daviess, Sept. 20, 6036; Ogle, Sept. 22, 6099. *Œnothera biennis:* Champaign, Sept. 19, 6616; Union, Sept. 3 (Earle).

The form on *Clematis* is referred by authors (Bessey, The Erysiphei, p. 13; Trelease, Parasitic Fungi of Wis., p. 9) to *E. tortilis*, (Wallr) Fr., or, as often written, *E. tortilis*, Link. It seems a mistake to separate it from the other forms occurring on *Ranunculaceæ*, some of which have equally long appendages; especially as on *Clematis* these are radiant, and more or less interwoven with the mycelium as is usual in *E. communis*, while in European specimens of *E. tortilis* on *Cornus* (Rabh. Fungi Europ. No. 2033; J. Kunze, Fungi Selecti Exsic., No. 577, etc.), the appendages are fasciculate and assurgent. (See also Tulasne, Selec. Fung. Carp., I., pp. 213–216).

The forms on *Leguminosæ*, etc., are often referred to *E. Martii*, Lév. De Bary (Morph. und Phys. der Pilze, III., p. 50) and Tulasne (l. c. p. 215) agree in considering this a synonym of *E. communis*. Winter, however, (Die Pilze, II., p. 31) retains *E. Martii* and refers to it all forms having hyaline appendages; but he says that he cannot decide whether this character is always constant and sufficient for their separation. Careful examination and comparison of the herbarium specimens specially mentioned by Winter, show that this character is not constant, for some of those given by him under *E. Martii* have distinctly colored appendages, while in some of those given under *E. communis* they are very slightly, if at all, colored. In fact the coloring of the appendages seems to depend, to a considerable extent, on the age and vigor of the specimen, being light colored or hyaline in the young, and often quite dark in fully matured, vigorous specimens. A portion, at least, of the appendages often remains hyaline on *Leguminosæ*, while on *Ranunculaceæ* they are usually all quite dark. All our specimens show more or less distinctly colored appendages.

E. galeopsidis, DC.

(Flore Franc., VI., p. 108.)

E. *lamprocarpa*, Lév., in part.
E. *labiatarum*, Chev. (Flora Paris, III., p. 380).

Amphigenous. Mycelium abundant, persistent, haustoria of the mycelial threads lobed; perithecia somewhat aggregated; appendages numerous, short, flexuous, colored, interwoven with the mycelium; asci numerous, often 12 or more; spores 2, mostly formed late.

On *Stachys palustris:* Henry, Sept. 28, 1705. *Stachys* sps.: Stephenson, Sept. 13, 5812. *Teucrium Canadense:* LaSalle, Sept. 29, 6239. *Scutellaria parvula:* Lee, Sept. 27, 6208. *Scutellaria lateriflora:* McLean, Sept. 6 (Seymour).

This can scarcely be separated from *E. cichoracearum* by the characters of the perithecia, but the difference in the haustoria, first pointed out by De Bary (Morph. und Phys. der Pilze, III., p. 49), can be observed by first soaking a portion of the leaf in caustic potash and then removing a little of the mycelium to the slide. In our specimens the perithecia and appendages are rather lighter colored than is usual in *E. cichoracearum.*

E. cichoracearum, DC.

(Flore Franc., II., p. 274.)

Alphitomorpha communis, γ depressa, horridula, Wallr. (Verhandl. Naturf. Freunde, IV).
Alphitomorpha lamprocarpa, Schl. (Verhandl. Naturf. Freunde, I., p. 49).
Erysibe communis, lamprocarpa, depressa, horridula, Lk. and Rabh.
Erysiphe horridula, Montagnei, lamprocarpa, Lév., in part.
Erysiphe ambrosiæ, verbenæ, phlogis, asterum, Schweinitz, (N. A. Fungi, p. 270).

Amphigenous. Mycelium abundant, persistent, haustoria rounded, not lobed; perithecia variable; appendages numerous, mostly short, 1–2 times the diameter of the perithecium, colored, much flexed and interwoven with the mycelium; asci

variable, 4 or 5 to as many as 20, mostly numerous; spores large, quite uniformly 2, but occasionally varying to 3 or even 4.

On *Napæa dioica:* Stephenson, Sept. 13, 5806. *Vernonia fasciculata:* Lake, Aug. 27, 1364; Rock Island, Sept. 23, 1630, Sept. 24, 1656; Tazewell, July 22, 2371; McLean, Oct. 12, 1850; Jersey, Oct. 13, 6289, Oct. 14, 6312; Union, Oct. 21, 1933; Pulaski, Nov. 4, 2234. *Eupatorium purpureum:* McLean, Aug. 1, 2366. *Aster sagittifolius:* McLean, Sept. 6, 5661. *Aster læris:* McLean, July 14, 5547. *Aster* sps: Kane, Aug. 30, 1376; Rock Island, Sept. 24, 1658, Sept. 27, 1691; Henry, Sept. 28, 1710; McLean, Oct. 11, 1833, 1835, Aug. 4, 2375; Stephenson, Sept. 13, 5804; Jo Daviess, Sept. 18, 5976; Champaign, Oct. 16, 6574; Union, Oct. 21, 1914, Oct. 24, 1964, Oct. 25, 2000, Oct. 27, 2065. *Solidago Canadensis:* Stephenson, Sept. 13, 5804. *Solidago* sps: Union, Oct. 24, 1972. *Ambrosia trifida:* La Salle, Sept. 12, 1484, 1494; Rock Island, Sept. 21, 1626; Henry, Sept. 28, 1704; McLean, Oct. 6, 1805, Oct. 13, 1865, Oct. 19, 1898; Jo Daviess, Sept. 15, 5903. *Ambrosia artemisiæfolia:* Rock Island, Sept. 23, 1632, Sept. 27, 1690; Fulton, Oct. 1, 1778; McLean, Oct. 6, 1806, Oct. 12, 1851; Champaign, Sept. 19, 6618; Union, Oct. 24, 1974, Oct. 25, 1998. *Xanthium strumarium:* Henry, Sept. 28, 1709; La Salle, Sept. 28, 6214, Sept. 30, 6246; Jersey, Oct. 12, 6278, Oct. 13, 6288. *Helianthus rigidus:* Boone, Sept. 2, 1421; La Salle, Sept. 12, 1491; Rock Island, Sept. 24, 1655; Henry, Sept. 28, 1720; Fulton, Oct. 1, 1782. *Helianthus decapetalus:* La Salle, Sept. 14, 1532; McLean, Oct. 6, 1807. *Helianthus tuberosus:* McHenry, Aug. 20, 1154. *Helianthus* sps: La Salle, Sept. 13, 1499; McLean, Oct. 11, 1837; Lee, Sept. 9, 5742; Jo Daviess, Sept. 16, 5944; Stephenson, Sept. 13, 5803; Ogle, Sept. 22, 6087, Sept. 25, 6164; *Actinomeris squarrosa:* La Salle, Sept. 14, 1531, 1543; Rock Island, Sept. 26, 1668; McLean, Oct. 6, 1808, Oct. 19, 1897; Union, Oct. 31, 2127; Stephenson, Sept, 2, 6072; Ogle, Sept. 25, 6165. *Cirsium discolor:* McLean, July 14, 5548, (immature); Stephenson, Sept. 13, 5805. *Hieracium Canadense:* McHenry, Aug. 20, 1215. *Verbena angustifolia:* Marion, Oct. 20, 1901; La Salle, Sept. 29, 6233; Jersey, Oct. 12, 6279; Ogle, Sept. 23, 6133. *Verbena hastata:* McHenry, Aug. 20, 1155;

Rock Island, Sept. 23, 1633; Fulton, Oct. 1, 1783; Jo Daviess, Sept. 20, 6025. *Verbena urticifolia:* Piatt, Aug. 15, 1072; McHenry, Aug. 20, 1228; La Salle, Sept. 13, 1513; Rock Island, Sept. 24, 1657; Fulton, Oct. 1, 1779; McLean, July 20, 2364, Oct. 12, 1849; Ogle, Sept. 23, 6132. *Verbena stricta:* Cook, Sept. 6, 1453; Jackson, Nov. 5, 2255; Jersey, Oct. 12, 6280. *Verbena bracteosa:* Adams, Aug. 25 (Seymour). *Hydrophyllum Virginicum:* Ogle, Sept. 25, 6153. *Phlox paniculata:* Adams (Seymour). *Phlox* sps: Fulton (Wolf). *Asclepias variegata:* Union, Sept. 22 (Earle). *Parietaria Pennsylvanica:* Stephenson, Sept. 21, 6069; Lee, Sept. 27, 6209. *Stevia* sps. (from greenhouse): Union (Earle).

This exceedingly abundant and widely occurring species is doubtless to be found on other hosts in this State besides those enumerated above. Although widely variable it is usually easily recognized by its short dark appendages and numerous two-spored asci. It is usually known as *E. lamprocarpa*, Lév. Winter, however (Die Pilze, II., p. 33), adopts De Candolle's name of *E. cichoracearum,* and according to the law of priority this seems to be correct.

The forms on various *Labiatæ* are often included here, but they differ in having lobed haustoria on the mycelium threads. On the various species of *Verbena* the haustoria are smooth and rounded as in the forms on *Compositæ*.

UNCINULA, LÉV.

(Ann. Sci. Nat., Ser. III., Tome XV.)

Perithecium containing several asci; appendages free from the mycelium, recurved or coiled at the tip.

U. ampelopsidis, Peck.

(Trans. Albany Inst., VII., p. 216.)

U. Americana, Howe (Erysiphei of U. S. in Jour. Bot. 1872).
U. spiralis, B. & C. (Grev. IV., p. 159).
U. subfusca, B. & C. (Grev. IV., p. 160).

Amphigenous or frequently epiphyllous. Perithecia 85–100 μ, dark brown, opaque, reticulations small, rather obscure; appendages from 10 or 12 to 20 or more, varying in

length from once and a half to four or more times the diameter of the perithecium, colored for more than half their length, frequently septate, occasionally forked, tips loosely and somewhat spirally coiled; asci mostly 4–6 (4–8 Farlow) ovate, pedicellate; spores 4–6.

Amphigenous: mycelium web-like, thin and evanescent; conceptacles minute, globose, black; appendages ten to twenty, in length once or twice the diameter of the conceptacle, simple, obscurely septate toward the base, colored, a little paler at the tips, sporangia four to six, subglobose or ovate containing four to six spores.—Peck, 25th Rep. N. Y. State Mus., p. 96.

On *Vitis* (cultivated): Union, Oct. 24, 1965, Oct. 28, 2071; Wabash (Schneck); Champaign (Burrill). *Ampelopsis quinquefolia:* McHenry, Aug. 20, 1203; La Salle, Sept. 12, 1483; Rock Island, Sept. 21, 1622; Lee, Sept. 8, 5700½; Ogle, Sept. 25, 6161; Champaign (Burrill).

The form on *Vitis*, which is one of the common "grape mildews," is usually known as *U. spiralis*, B. & C. Aside from its usually somewhat longer appendages, there seems to be no way of distinguishing it from the previously described form on *Ampelopsis.* The appendages in each are colored, frequently septate, and similarly coiled at the tip, while the cellular structure of the walls of the perithecium, and the characters of the spores and asci, are indistinguishable. In specimens on *Vitis* from Massachusetts (Seymour), the appendages are mostly very long: but in the Illinois specimens they are frequently not more than twice, or sometimes only once and a half, the diameter of the perithecium; while on *Ampelopsis* they are frequently as much as two, two and a half, or even three times the diameter.

U. macrospora, Peck.

(Trans. Albany Inst., VII., p. 215.)

Amphigenous. Mycelium conspicuous, abundant; perithecia large, 110–140 μ, wall tissue soft, reticulations very small, 5–10 μ, and rather obscure; appendages very numerous, 50 or more, hyaline, slender, smooth, usually shorter than the diameter of the perithecium, tip closely coiled, not enlarged; asci several, 8–10; spores 2, large, 20 by 30–35 μ.

Mycelium effused, persistent; conceptacles subglobose; appendages numerous, thirty or more, about equal in length to the diameter of the conceptacle; sporangia eight to twelve; spores two, very large, elliptical, .0012–.0015 inch long.– Peck, 25th Rep. N. Y. State Mus., p. 96.

On *Ulmus Americana:* Fulton, Oct. 1, 1776, 1781; McLean, Oct. 12, 1852. *Ulmus alata:* Union, Oct. 2, 6547. Oct. 21, 1916, 1934, Oct. 22, 1962, 2377, Oct. 25, 2023, Oct. 28, 2073, 2091.

This abundantly occurring species differs sufficiently from European specimens of *U. Bivonæ*, Lév. on *Ulmus campestris* (Thüm. Mycoth. Univer. No. 755). In these the perithecia are smaller (80–90 μ), and the reticulations are much larger (10–15 μ) and more distinct. The fewer (less than 20) appendages are stouter, somewhat roughened and conspicuously swollen at the tip. The usually four asci each contain two spores about 30 μ long but narrower than in *U. macrocarpa.*

U. flexuosa, Peck.

(Trans. Albany Inst., VII., p. 215.)

Hypophyllous. Perithecia large 110–125 μ, dark, opaque, reticulations obscure; appendages numerous, 40 or more, about equaling the diameter of the perithecium, hyaline, minutely roughened, thickened and irregularly flexuous toward the tip; asci about 10, ovate or pyriform, strongly pedicellate; spores 8, small, 15–20 μ long.

The wavy-flexuous appendages are peculiar to this species, and with its more numerous spores separate it from *U. adunca* Lév. to which it is sometimes referred.—Peck, 26th Rep. N. Y. State Mus. p. 80.

On *Æsculus* sps.: Union, Sept. 15 (Earle).

This handsome and peculiar species is well characterized by the several abrupt changes of direction in the upper half of the appendage, which give it a peculiar wavy outline.

U. circinata, C. & P.

(Erysiphei of the U. S. in Jour. of Bot. 1872.)

Hypophyllous. Mycelium inconspicuous; perithecia very large, depressed, 150–175 μ in greatest diameter, texture soft, reticulations very small and irregular; appendages very numer-

ous, slender, simple, about equal to the diameter of the perithecium, hyaline, smooth, tips not swollen, ascending from the upper half of the perithecium; asci numerous, 14 or more, long and slender, oblong or narrowly ovate, pedicellate, about 30 by 75 μ; spores 8, small, about 10 by 15 μ.

Mycelium dense, effuse, persistent; conceptacles large, depressed or flattened, black; appendages very numerous, slender, about equal in length to the diameter of the conceptacle, simple, colorless; sporangia oblong or narrowly ovate, eight to sixteen, containing eight spores.—Peck, 25th Rep. N. Y. State Mus. p. 26.

On *Acer saccharinum:* Champaign, Oct. 17 (Waite).

This is distinguished from *U. aceris*, (DC.) Lév. by its simple appendages, and more numerous, very narrow asci. In our specimens the mycelium is quite inconspicuous, but in specimens from Massachusetts (Seymour) it is more abundant. The leaves affected by it can be distinguished at some distance, as the areas covered by it remain green after the rest of the leaf has assumed its autumn tint. (Waite.)

U. parvula, C. & P.

(Erysiphei of the U. S. in Jour. of Bot. 1872.)

Amphigenous. Perithecia small, 90–100 μ, delicate, reticulations distinct, small and regular, averaging about 10 μ; appendages very numerous, delicate, slender, hyaline, shorter than the diameter of the perithecium; asci 5–7, broadly elliptic; spores 6–8, mostly 6, large, 20–25 μ long.

Hypophyllous; mycelium effused, delicate, evanescent; perithecia scattered, globose, minute; appendages simple, numerous, scarcely so long as the diameter of the perithecia; asci elliptical, rostrate; spores 6.—Cooke and Peck, Erysiphei of the U. S., Supp. in Jour. of Bot., June, 1872.

On *Celtis occidentalis:* Union, Oct. 26, 2036; Oct. 31, 2144; Jackson, Nov. 5, 2264.

This is perhaps too near *U. Salicis*, (DC.) Winter, but it seems to be distinguished by its uniformly smaller size and its shorter, more delicate appendages.

U. salicis, (DC.) Winter.

(Die Pilze, II., p. 40.)

Erysiphe salicis, DC. (Flore Franc., II., p. 273).
Erysiphe populi, DC. (Flore Franc., VI., p. 104).
Alphitomorpha adunca, guttata, Wallr. (Verh. Naturf. Freunde, I., pp. 37, 42).
Erysibe adunca, obtusata, Lk. (Spec. Plant., VI., 1, p. 117).
Erysiphe adunca, Grev. (Scott. Crypt. Flora, V., tab. 296).
Uncinula adunca, Lév. (Ann. Sci. Nat., Ser. III., Tome XV).
Uncinula leuculenta, Howe (Trans. Albany Inst., VII., quoted in Amer. Nat., VII., p. 58).
Uncinula heliciformis, Howe (Torr. Bull., V., p. 4).

Amphigenous. Mycelium abundant, persistent; perithecia usually large, 100–160 μ, wall-tissue soft, elastic, reticulations rather small and indistinct; appendages variable in number, usually very numerous, hyaline, not much swollen at the tip, once to twice as long as the diameter of the perithecium; asci from 4 or 5 to 12 or more, ovate; spores usually 4 or 5, sometimes 6–8.

On *Salix* sps.: La Salle, Sept. 20, 1602; Henry, Sept. 28, 1721; Jo Daviess, Sept. 20, 6029, 6030, 6031; Stephenson, Sept. 21, 6083. *Salix petiolaris:* Piatt, Aug. 17, 1143. *Salix cordata:* McHenry, Aug. 20, 1152, Aug. 24, 1255, 1256; Cook, Sept. 5, 1435; Jo Daviess, Sept. 18, 5974. *Populus tremuloides:* McHenry, Aug. 23, 1250, Aug. 31, 1397; Jo Daviess, Sept. 18, 6018. *Populus grandidentata:* La Salle, Sept. 17, 1579. *Populus heterophylla:* Union, Oct. 25, 2020, 2031; Oct. 31, 2142.

This species is quite variable, as are most of the abundant and widely distributed ones belonging to the family. It is usually known as *U. adunca*, Lév.; but De Candolle's name has priority, and is adopted by Winter (Die Pilze, II., p. 40) and Tulasne (Fung. Carp. I., p. 198). The asci are usually described with only four or five spores, but our specimens frequently show as many as six, and sometimes seven or eight.

U. leuculenta, Howe, is described as occurring on *Populus*, with fewer and longer appendages and five or six spores. Illinois specimens on *Populus* sometimes show rather longer appendages than on *Salix*, but as the more numerous spores are frequent on both hosts, there is no sufficient ground for sepa-

rating them. Trelease (Parasitic Fungi of Wis., p. 8) gives *U. heliciformis* Howe, as a synonym for *U. adunca.* Howe's description says, "appendages colored at base;" but this alone would not be a sufficient specific character. There is nothing else in the description by which to distinguish it from the other forms on *Populus.*

PHYLLACTINIA, LÉV.

(Ann. Sci. Nat., Ser. III., Tome XV., p. 144.)

Perithecium containing several asci; appendages free from the mycelium, acicular, acute at the tip, abruptly swollen at base.

P. suffulta, (Reb.) Sacc.

(Syl. Fung., I., p. 5.)

Sclerotium suffultum, Rebent. (Flor. Neom., p. 360).
Erysiphe coryli, fraxini, DC. (Flore Franc., II., p. 273).
Erysiphe vagans, Bivon. (Stirp. rar. Sicil., III., p. 19).
Alphitomorpha guttata, Wallr. (Verh. Naturf. Freunde, I., p. 42).
Erysibe guttata, Lk. (Spec. Plant., VI., 1, p. 116).
Erysibe guttata, Fr. (Syst. Mycol., III., p. 245).
Phyllactinia guttata, Lév. (Ann. Sci. Nat., Ser. III., Tome XV).

Hypophyllous. Mycelium abundant, persistent, or scant and evanescent: perithecia very large, 150–250 μ, wall tissue soft, cellular structure and reticulations obscure; appendages few, usually 8–12, easily detached, hyaline, varying in length from less than to three or four times the diameter of the perithecium; asci 4 or 5 to 20 or more, ovate, pedicellate; spores normally 2, occasionally 3 or 4, variable in size, mostly quite large.

On *Liriodendron tulipifera:* Union, Oct. (Earle). *Celastrus scandens:* Jersey, Oct. 14, 6307. *Cratægus tomentosa* var. *pyrifolia:* Champaign, Oct. 18 (Seymour). *Cornus Florida:* Union, Oct. 2, 6544. *Ilex decidua:* Union, Oct. 7 (Earle). *Catalpa bignonioides:* Champaign, Oct. 10, 6577½. *Fraxinus* sps.: Union, Sept. (Earle); Champaign, Oct. (Waite). *Ulmus Americana:* Jersey, Oct. 12, 6277. *Ulmus alata:* Union, Oct. 2, 6543, Oct. 22, 2377. *Quercus macrocarpa:* Union, Oct. 21, 1917, Oct. 28, 2090, 2105. *Quercus coccinea:* Union, Oct. 31, 2139; Champaign, Oct. 30, 6377. *Quercus tinctoria:*

Union, Sept. and Oct. (Earle). *Quercus rubra:* Union, Nov. 1, 2196. *Quercus (palustris?):* La Salle, Sept. 17, 1582. *Fagus ferruginea:* Union, Sept. 20 (Earle). *Corylus Americana:* Lee, Sept. 12, 5794; Jo Daviess, Sept. 16, 5940; Ogle, Sept., 6192; Union, Sept. and Oct. (Earle). *Betula nigra:* Jersey, Oct. 14, 6306; Union, Oct. 4, 6561.

This frequently occurring species presents many variations in the size of the perithecia, the length of the appendages, the number and size of the asci, and the size of the spores; but none of these forms seem constant enough to justify their separation. On *Liriodendron* the mycelium is usually inconspicuous, the appendages but little longer than the diameter of the perithecium, and the few (8–10) asci are large and broadly ovate. On *Ulmus* the mycelium is abundant and persistent, the perithecia and appendages medium, and the very numerous (20–30) asci are small and narrow. On *Quercus* the perithecia are very large, and the 10–15 asci and the spores are much larger than on *Ulmus*. On *Corylus* the perithecia are small, but the appendages are very long. Asci and spores not observed on this host. They seem to mature later than on the others.

This species has long been known as *P. guttata*, Lév., but priority demands the use of the name given by Rebentisch, (Sacc. Syl. Fung., I., p. 5).

The peculiar yellow oil often occurring in the perithecia of this family is here particularly abundant and noticeable. In some cases, especially on *Ulmus*, the leaves affected by the fungus turn yellow and fall prematurely.

PODOSPHÆRA, Kunze.

(Mycol., Hefte II., p. 111.)

Perithecium containing a single ascus; appendages free from the mycelium, dichotomously branched at the end.

P. oxyacanthæ, (DC.) DBy.

(Morph. und. Phys. der Pilze, III., p. 480.)

Erysiphe oxyacanthæ, DC. (Flore Franc., VI., p. 106).
Alphitomorpha tridactyla, clandestina, Wallr. (Flore Crypt. Germ., III., p. 753).

Erysibe tridactyla, Rabh. (Deutschl. Krypt. Fl., I., p. 273).
Erysibe clandestina, Lk. (Spec. Plant., VI., I., p. 103).
Podosphæra Kunzei, clandestina, Lév. (Ann. Sci. Nat., Ser. III., Tome XV).
Podosphæra trydactyla, myrtillina, DBy. (l. c., III., p. 48).
Podosphæra myrtillina, Kunze (Mycol., Hefte II., p. 111).
Podosphæra minor, Howe (Torr. Bull., V., p. 3).

Amphigenous. Mycelium variable, often abundant, persistent, perithecia 65–110 μ. dark, opaque, reticulations regular, about 10–15 μ, evident when young, scarcely observable when old, except by the uneven surface; appendages 8–20, dark brown for more than half their length, frequently septate, 1–4 times as long as the diameter of the perithecium, 3–5 times dichotomously forked, branches short, often swollen, tips recurved; ascus broadly elliptic or orbicular, about 50 by 60 μ, thick walled; spores usually 8.

On *Cratægus tomentosa* var. *pyrifolia:* Union, Nov. 3, 2194; Adams, July 3, 5394. *Cratægus* sps*:* Union, Sept. (Earle). *Prunus Anericana:* Lee, Sept. 9, 5744. *Prunus cerasus* (cultivated): McHenry, Aug. 24, 1289; Rock Island, Sept. 21, 1625; Piatt, Aug. 16, 1151; Adams, June 29, 5342; Union, Aug. 22 (Earle).

European botanists agree in dividing what is here included under *P. oxyacanthæ,* into three species, as follows:—

P. oxyacanthæ, (DC.) DBy. Appendages 8 or more, about equal to the diameter of the perithecium, standing erect on its upper surface. On *Cratægus*, *Sorbus*, and *Mespilus.*

P. tridactyla, (Wallr.) DBy. Appendages 3–7, standing erect in a parallel bundle on the summit of the perithecium. On *Prunus* sps.

P. myrtillina, (Schubert) Kunze. Appendages 6–10, arising from the upper surface of the perithecium, but radiating divergently or reflexed. On *Vaccinium.*

European specimens on the above hosts show these distinguishing characters sufficiently well. American specimens on *Prunus* often have as many as twenty appendages, and though they all stand on the upper half of the perithecium it is only in rare cases that they are collected in an erect cluster at the summit, as in *P. tridactyla.* They usually radiate even more divergently than in *P. myrtillina.* In American specimens on *Cratægus*

the appendages average a little shorter than on *Prunus*, but they show no other appreciable differences. In both cases they are too variable for this to constitute a distinguishing characteristic.

As our specimens thus present intermediate forms connecting those that are separated in Europe, it becomes necessary to consider them all as belonging to one variable species. Widely varying species are common among the *Erysipheæ*, and the forms included here differ much less widely than those that are referred to *Erysiphe communis* or *Phyllactinia suffulta*. As De Candolle's name has priority, it must be retained.

MICROSPHÆRA, Lév.

(Ann. Sci. Nat., Ser. III., Tome XV.)

Perithecium containing several asci; appendages free from the mycelium, more or less dichotomously branched at the end.

Key to the Illinois Species of Microsphæra.

I. Tips of the appendages not recurved.................A.
II. Tips of the appendages recurved when mature........B.
  A. Appendages colored..............................1.
  Appendages hyaline or nearly so.................2.
    1. Appendages short (equal to diameter of perithecium).........................M. SEMITOSTA.
    Appendages very long (4–6 times diameter of perithecium)....................M. RUSSELLII.
    2. Appendages medium (2–3 times diameter of perithecium) .... { M. DIFFUSA. M. SYMPHORICARPI.
    Appendages long (3–6 times diameter of perithecium)........ { M. VACCINII. M. EUPHORBIÆ.

B. Appendages colored .... M. ERINEOPHILA.
Appendages mostly hyaline .... 2.
2. Appendages short (2 times diameter of perithecium, or less) ..... { M. RAVENELII. / M. ALNI.
Appendages usually long (2–4 times diameter of perithecium) .... { M. QUERCINA / M. ELEVATA.

A. *Tips of the appendages not recurred.*
1. *Appendages colored.*

M. semitosta, B. & C.
(Grev. IV., p. 160.)

Epiphyllous. Mycelium persistent; perithecia few, somewhat aggregated, 90–100 μ, delicate, reticulations regular and distinct, about 10 μ; appendages 12 or more, about equal to the diameter of the perithecium, colored throughout, paler toward the tip, or the color stopping at a distinct line like a septum, 3 or 4 times dichotomously branched, primary branches long, others short, tips obtuse, not recurved; asci—; spores small, 10 by 15 μ.

Mycelium sparing; appendages forked three times, more than twice as long as the diameter of the perithecia; abruptly brown at the base; sporidia 4.—Berkeley, l. c.

On *Cephalanthus occidentalis:* Champaign, Oct. (Waite).

In the specimens at hand the number of asci and spores cannot be determined. Compared with the description by Berkeley, the appendages are not so long, and only part of them show the abrupt termination of the coloring.

M. Russellii, Clinton.
(26th Rep. N. Y. State Mus., p. 80.)

Amphigenous. Mycelium inconspicuous; perithecia small, 75–100 μ, delicate, reticulations regular, distinct, about 10 μ; appendages 8–18, many times longer than the diameter of the perithecium, colored for half or two thirds of their length, occasionally septate, simple, bifid, or two or three times irregularly branched, branches long, often distorted, tips not swollen or recurved; asci 4–8; spores usually 4, small.

Amphigenous; mycelium arachnoid, evanescent, appendages 8–18, very long, flexuous, colored, paler toward the tips, which are simple or one to three times divided; sporangia ovate, 4–8; spores 4, elliptical, .0007–.0008 in. long.—Peck 26th Rep. N. Y. State Mus., p. 80.

On *Oxalis stricta:* McLean, Oct. 7, 1827.

The appendages, from their length and manner of branching, much resemble those of *M. euphorbiæ*, but they are strongly colored, and the perithecia are smaller and more delicate.

2. *Appendages hyaline or nearly so.*

M. diffusa, C. & P.

(Erysiphei of the U. S., in Jour. of Bot. 1872.)

Usually epiphyllous. Perithecia scattered, 100–120 μ, dark, opaque, reticulations rather obscure, 10–15 μ; appendages 15–25, hyaline, or slightly tinted at base, 2–4 times as long as the diameter of the perithecium, once to four or five times irregularly or dichotomously branched, branches long and diffusely spreading, not at all swollen or recurved; asci 4–7, ovate pedicellate, rather small, 30–35 by 60–65 μ; spores 4–8, mostly 4–5.

Mycelium thin, evanescent; conceptacles minute, globose, black; appendages numerous, eighteen to twenty-five, in length once or thrice the diameter of the conceptacle, somewhat irregularly divided and slightly nodulose at the tips; sporangia ovate, four to six, containing four to six spores.—Peck, 25th Rep. N. Y. State Mus., p. 95.

On *Desmodium cuspidatum:* Jo Daviess, Sept. 20, 6041; Champaign, Sept. 18, 6617, Oct. 25, 6599. *Desmodium Canadense:* Lee, Sept. 12, 5793; Stephenson, Sept. 13, 5807, Sept. 21, 6073; Jo Daviess, Sept. 18, 5970, 5972, 6001: Ogle, Sept. 22, 6089. *Desmodium paniculatum:* Jo Daviess, Sept. 18, 5973. *Desmodium* sps.: Union (Earle). *Lespedeza capitata:* Ogle, Sept. 23, 6136. *Lespedeza hirta:* Union, Sept. 20 (Earle). *Phaseolus perennis:* Union (Earle).

This species seems to be well characterized by the long, lax branching of the appendages. In Illinois specimens on *Desmodium* the appendages are usually 2–2½ times the diameter of the perithecium; but on *Phaseolus*, some of them are 3½ times

the diameter, and in specimens on *Lespedeza capitata* from Wisconsin (Pammel), which otherwise agree with this species, the appendages are five or six times the diameter.

M. symphoricarpi, Howe.
(Torr. Bull., V., p. 3.)

Amphigenous. Mycelium abundant, persistent; perithecia small, 80–100 μ, delicate, reticulations large, regular, 15–20 μ; appendages 8–16, hyaline or slightly colored at base, 2–4 times as long as the diameter of the perithecium, 4–5 times dichotomous, branches short, compact, tips truncate, somewhat swollen, not recurved; asci 4–10, small, 50 μ long; spores 4–6, small and narrow, 10–18 μ.

Mycelium effused, sub-persistent; perithecia scattered or crowded; appendages 8–14, 2–4 times the length of the diameter of the perithecia, 3–5 times dichotomous, ramuli divaricate, tips variable, often truncate, never curved; asci 4–6; spores 3–5.— Howe, Torr. Bull., V., p. 3.

On *Symphoricarpus vulgaris:* Piatt, Aug. 15, 1074, Aug. 16, 1099; McLean, July 29, 2372. *Symphoricarpus* sps.: Union, Nov. 1, 2184.

This is much like some forms of *M. vaccinii*, but the mycelium is more abundant and the reticulations are larger and more evident.

M. vaccinii, C. & P.
(Erysiphei of the U. S., in Jour. of Bot. 1872.)

Erysiphe vaccinii, Schw. [?] (N. A. Fungi, p. 270).

Amphigenous. Mycelium thin and delicate, often evanescent, or sometimes abundant, peristent; perithecia variable, often small, 80–90 μ, or large, 110–120 μ, fragile; appendages 10–20, hyaline, smooth, slightly colored at base, 2 or 3 to as many as 6 times the diameter of the perithecium, branching various, usually 3 or 4 times forked, with the tips truncate or bifid, not recurved, occasionally more ornate, with tip distinctly recurved; asci 4–8, small and broad, about 40 by 55 μ; spores 4–6 small.

Amphigenous; mycelium arachnoid, evanescent; perithecia globose, scattered; asci 6 to 8; spores 6 to 8; appendages rather numerous (12 to

20) 4 to 6 times as long as the diameter of the perithecia; 3 to 4 times dichotomously branched above, tips swollen.—Cooke and Peck, Erysiphei of U. S., in Jour. Bot. 1882.

On *Gaylussacia resinosa:* Ogle, Sept. 25, 6173; La Salle, Sept. 30, 6247. *Vaccinium (vacillans?):* Jersey, Oct. 14, 6318.

This is a variable species not only in the character of the mycelium, but in the length and branching of the appendages. In most cases the tips are swollen, and not at all recurved. There is some confusion in regard to the authority for this species. Schweinitz (N. A. Fungi, p. 270) describes an *Erysiphe vaccinii* on *Vaccinium Pennsylvanicum* from Berks Co., Penn., while Peck (23d Rep. N. Y. State Mus., p. 65) refers specimens on *Epigæa repens* to *Erysiphe vaccinii*, Schw., and on the same page describes *Microsphæra vaccinii* on *Vaccinium vacillans* as a new species. This report was submitted for publication in 1870, but was not printed until three years later. During this interval the species was published jointly by Cooke and Peck in the Journal of Botany (Jan. 1872). As Schweinitz's specimens were on *Vaccinium*, it is very probable that they belonged to this species rather than to the one on *Epigæa*. This point can probably never be satisfactorily settled, so it is best to write simply *M. Vaccinii*, C. & P.

M. euphorbiæ, B. & C.

(Grev. IV., p. 160.)

Amphigenous. Mycelium abundant, persistent; perithecia scattered, abundant, usually small, 80–100 μ, but often larger (120 μ), texture soft, elastic, reticulations 10–15 μ, frequently obscure; appendages 15–20, very long, 5–6, or more times, the diameter of the perithecium, hyaline, often slightly tinted at base, irregularly flexuous and often nodularly swollen, at first simple, then part of them bifid or three or four times dichotomous, branches long, lax, tips sometimes bifid, but not swollen or recurved; asci 4–8, frequently 6, pedicellate, 35–40 by 65 μ; spores 4–6.

Mycelium ample; appendages many times longer than the diameter of the perithecia, once or twice forked, then lobed at the tips.—Berkeley, Grev. IV., p. 160.

On *Euphorbia hypericifolia:* Union, Oct. 24, 1931. *Euphorbia corollata:* McHenry, Aug. 20, 1198, Aug. 26, 1294, Sept. 1, 1411; Boone, Sept. 2, 1418; McLean, Oct. 7, 1821, Oct. 12, 1842; Union, Oct. 21, 1938, Oct. 25, 2005, Oct. 29, 2117; Lee, Sept. 11, 5778; Jo Daviess, Sept. 16, 5943, Sept. 18, 5971.

This is very common throughout the State, and is easily recognized by its very long, often unbranched, colorless appendages. Such appendages are also characteristic of the European species *M. Astragali*, (DC.) Trev. Our specimens closely resemble specimens of the latter on *Astragalus glycyphyllus.*

B. *Tips of appendages distinctly recurved when mature.*

M. erineophila, Peck.

(Torr. Bull., X., p. 75.)

Mycelium thin; perithecia 90–100 μ, fragile, dark, opaque, reticulations obscure; appendages few, 8–12, dark colored except the branches, scarcely equal to the diameter of the perithecium, 4–6 times regularly dichotomous, branches short and rather thick, tips recurved; asci 5–8, oval or ovate, pedicellate, rather small, 35 by 55 μ; spores uniformly 8, small.

Mycelium arachnoid, sub-persistent; perithecia .003 to .004 of an inch broad, sometimes collapsed or pezizæform; appendages 6 to 12, shorter than, or about equal to, the diameter of the perithecia, colored, the tips paler and two or three times dichotomous; asci 4, sometimes 3 or 5, eight-spored; spores .0008 to .0009 of an inch long, .00045 to .0005 broad, usually containing one or two large nuclei.—Peck, Torr. Bull., X., p. 75.

On the "*Erineum*" caused by some species of *Phytoptus* on the lower sides of the leaves of *Fagus ferruginea:* Union, Aug. 20, Sept. 20 (Earle); Pulaski, Nov. 4, 2230, 2244, 2245.

This peculiar species is not uncommon in southern Illinois. So far as is known it has not been collected elsewhere. It has been distributed by Winter as No. 3245 of his "Fungi Europ. et extra Europæi."

2. *Appendages mostly hyaline.*

M. Ravenelii, Berk.
(Grev. IV., p. 160.)

Amphigenous. Mycelium usually abundant, persistent; perithicea abundant, usually large, 100–130 μ, reticulations small and irregular, about 10 μ; appendages 10–20, somewhat roughened, usually hyaline, occasionally colored for a distance, the color ending at an abrupt line like a septum, once or twice as long as the diameter of the perithecium, 5–7 times dichotomous, branches short, forming a more or less compact head, tips not swollen at length, usually acute and recurved; asci 6–10, frequently 8, ovate pedicellate, about 45 by 60 μ; spores 4–6 (Saccardo says 8).

Mycelium effused, dirty white; appendages repeatedly forked toward the apex, much more so than in the last (*M. penicillata* Lév).—Berkeley, Grev. IV., p. 160.

On *Gleditschia tricanthos:* Piatt, Aug. 16, 1100; Fulton, Oct. 1, 1780; McLean, Aug. 6, 2363, Oct. 6, 1861; La Salle, Sept. 29, 6237; Jersey, Oct. 13, 6286. *Lathyrus palustris:* Champaign, Oct. (Waite). *Vicia Americana:* McHenry, Aug. 20, 1211.

In the typical form of this species, that on *Gleditschia*, the peculiarly colored appendages mentioned in the description seldom occur, but they may occasionally be noticed. On *Vicia* a majority of the appendages are colored in this manner, and the mycelium is rather less abundant. In other respects it agrees so closely with *M. Ravenelii* that it does not seem best to separate it, especially as the appendages are not all colored on *Vicia* while they are occasionally colored on *Gleditschia*. The form on *Lathyrus* stands about half way between the other two in the coloring of the appendages and density of the mycelium. A form on *Lathyrus* has been referred by Trelease (Parasitic Fungi of Wisconsin, p. 8.) to *M. diffusa*, C. & P. It seems from his note to be the same as our form on this host. Our specimens of *M. diffusa* on *Desmodium*, *Lespedeza*, and *Phaseolus* closely agree in the long and loose branching of their appendages, a character well expressed by the specific name, and

the tips, even in the most mature specimens, are not at all recurved. This is clearly different from the regular and compact branching and recurved tips of the appendages on *Lathyrus*, which, as Trelease himself observes, "closely resemble those of *M. Ravenelii*, B."

M. alni, (DC.) Winter.
(Die Pilze, II., p. 38.)

Erysiphe alni, betulæ, DC. (Flore Franc., VI., pp. 104–107).
Alphitomorpha penicillata, Wallr. (Verhandl. Naturf. Freunde, I., p. 40).
Erysibe penicillata, Lk. (Spec. Plant., VI., I., p. 113).
Erysiphe viburni, Duby (Bot. Gall., II., p. 872).
Erysiphe ceanothi, viburni, syringæ, Schw. (N. A. Fungi, pp. 269, 270).
Microsphæra Hedwigii, penicillata, Friesii, Lév. (Ann. Sci. Nat., Ser. III., Tome XV).
Microsphæra platani, Howe (Torr. Bull., V., p. 4).
Microsphæra Van Bruntiana, Ger. (Torr. Bull., VI., p. 31).
Microsphæra viburni, Howe (Torr. Bull., V., p. 43).
Microsphæra pulchra, C. & P. (Erysiphei of U. S., in Jour. of Bot., 1872).

Amphigenous. Mycelium often delicate and evanescent, sometimes abundant and persistent; perithecia usually small, 80–100 μ, sometimes large, 100–130 μ, wall tissue compact, rather fragile, reticulations not large, 10–15 μ; appendages 6 or 8 to 15 or 20, hyaline, usually tinted at base, often somewhat roughened, usually about equaling, but varying from less than to more than twice the diameter of the perithecium, 4–6 times dichotomous, branches varying in length and angle of divergence, but always regular and symmetrical, tips acute, distinctly, often strongly, recurved; asci varying with the size of the perithecium from 2 or 3 to 8 or more, usually 4 or 5, ovate when numerous, suborbicular when few; spores 4–8, variable, mostly small, averaging about 20 μ long.

On *Ceanothus Americanus:* Stephenson, Sept. 21, 6082; Ogle, Sept. 22, 6090, Sept. 23, 6135. *Euonymus atropurpureus:* La Salle, Sept. 17, 1580; Champaign, Aug. 12, 1057. *Lonicera flava* (cultivated): Champaign, Oct. 9, 2381. *Viburnum pubescens:* McHenry, Aug. 24, 1262. *Viburnum prunifolium:* Jo Daviess, Sept. 18, 5969; Champaign, Oct. (Waite). *Ilex*

decidua: Union, Oct. 25, 2014; Jersey, Oct. 13, 6287. *Ulmus Americana*, Jo Daviess, Sept. 19, 6003. *Syringa vulgaris:* McHenry, Aug. 20, 1173, 1214, Aug. 31, 1398; Cook, Sept. 8, 1464; La Salle, Sept. 12, 1500; Rock Island, Sept. 21, 1623; McLean, Oct. 18, 1872, Aug. 18, 5632; Union, Nov. 1, 2185; Jackson, Nov. 5, 2260; Jo Daviess, Sept. 20, 6039. *Platanus occidentalis:* Champaign, Oct. 30, 6375; Union, Sept. & Oct. (Earle). *Juglans cinerea:* Union, Sept. 22 (Earle). *Juglans nigra:* Union, Oct. 22 (Earle). *Carya alba:* Union (Earle). *Corylus Americana:* McHenry, Aug. 20, 1169, Aug. 24, 1287; Lee, Sept. 12, 5790; Stephenson, Sept. 14, 5879, Sept. 24, 6066; Jo Daviess, Sept. 16, 5941, Sept. 19, 6000; Ogle, Sept. 25, 6174.

The forms here included under *M. alni* have been assigned by different authors to various species, distinguished, for the most part, by the number of the asci and spores. In all of these forms the size of the perithecia, even when standing side by side on the same leaf, is quite variable, and, as a consequence, the number and shape of the asci they contain vary equally widely. Very small perithecia contain only a few (2–4) suborbicular asci, while larger ones contain a greater number, which, owing to lateral crowding, are narrower and longer. The spores are by no means constant in number, even in asci from the same perithecium. It is manifestly impossible to maintain specific distinctions based on such variable characteristics; and it becomes necessary, as in other genera of the family, to combine these rather widely varying forms. Aside from the number of asci and spores, the forms included here do not, however, present any very wide variations. In fact the branching of the appendages, and the cellular structure of the wall of the perithecium, are strikingly alike in all of them. The specimens collected in Union county, on *Juglans cinerea* and *J. nigra*, are sometimes very different from the type, having appendages less than the diameter of the perithecium. But on these same hosts other forms imperceptibly grade into the characteristic ones, leaving no room for specific distinction.

The form on *Syringa* is usually known as *M. Friesii*, Lév.; that on *Viburnum* as *M. viburni*, Howe; that on *Sambucus* as *M. Van Bruntiana*, Ger.; and that on *Platanus* as *M. platani*, Howe. The others are usually referred to *M. penicillata*, Lév.

It is unfortunately necessary to discard this last well-known name in favor of the one previously given by De Candolle to one of the many forms of the species. This is to be regretted the more as the name, *alni*, taken from only one among so many hosts, fails to express any true characteristic of the species as now understood. Some writers whose opinions carry great weight in all matters concerning fungi, would consider this sufficient ground for disregarding the law of priority, and would select from the names that had been given to the species, the one that seemed to them to be most appropriate, even going so far as to give a plant an entirely new name, because found to occur on other hosts than the one from which its name was derived. The case of *Phytophthora omnivora*, De Bary, may be taken to illustrate this usage. Hartig described a parasite occurring on young birch seedlings as *Peronospora fagi* (Zeitschr. f. Forst- und Jagdwesen., VIII. (1875), p. 121). Schenk described a similar parasite on *Sempervivum* as *Peronospora sempervivi* (Sitzungsber. d. Naturf. Gesellschaft zu Leipzig, July, 1875). De Bary (Morph. und Phys. der Pilze, IV., pp. 22–27) finds these two species to be identical, and that the same thing also occurs on *Clarkia*. He, therefore, in transferring them to his new genus, *Phytophthora*, writes *P. omnivora*, entirely disregarding both of the previously given names, although, in this case, there could be no question of the identity of the forms first described, but only of the appropriateness of the older names in the light of the increased knowledge of the species.

While it is doubtless very desirable to have species appropriately named, it is easy to see that this practice, if usually followed, would lead to endless confusion; for each addition to our knowledge of a species would necessitate, or at least permit, a change of name. Here, as in other branches of biology, the only safe rule seems to be to adhere rigidly to the law of priority whenever the older name is at all admissible. If this species never occurred on *Alnus* the retention of the name *M. alni* would be much more questionable.

This species is not reported as occurring on *Syringa*, in Europe, although abundant there on other hosts. This seems singular when it is remembered how frequently our lilacs are attacked by it, and naturally leads to the question whether,

after all, this form may not be distinct. In the present state of our knowledge, the classification of these minute plants is necessarily based almost entirely on their morphological characters; and as there are no constant differences of form by which they can be distinguished, it is necessary to consider them identical until the contrary is proved by a careful study of their development and life history.

M. quercina, (Schw.) Burrill.

(N. A. Fungi, p. 270.)
Erysiphe quercinum, Schw. (N. A. Fungi, p. 270).
Microsphæra extensa, C. & P. (Erysiphei of U. S., in Jour. of Bot., 1872).
Microsphæra abbreviata, Peck (28th Rep. N. Y. State Mus., p. 64).

Ephiphyllous, hypophyllous, or amphigenous. Mycelium abundant, rather thin and pruinose, forming orbicular patches or spreading over the whole surface of the leaf; perithecia abundant, scattered, varying from 80–140 μ, reticulations evident, small, and irregular; appendages less than 20, varying in length from less than, to 4 or 5 times, the diameter of the perithecium, hyaline, often tinted at base, smooth or sometimes roughened, usually regularly 5–6 times dichotomous, branches short and tips strongly recurved, but presenting many curious and ornate variations caused by the more extended or unequal growth of some of the branches; asci 3–8, often rupturing by slight pressure; spores 4–8, variable, usually large, 20–30 μ long.

M. extensa, C. & P. Mycelium thin, effuse, persistent; conceptacles globose, black; appendages eight to twelve, in length three or four times the diameter of conceptacle, colorless; sporangia four, subglobose or ovate, containing four to six spores. Upper surface of oak leaves. *Quercus rubra.*—Peck, 25th Rep. N. Y. State Mus., p. 95.

M. abbreviata, Peck. Mycelium thin; conceptacles small; appendages six to fifteen, hyaline, rough, shorter than the diameter of the conceptacles, many times dichotomous at the tips, the ultimate ramulæ curved; sporangia three or four, containing three to five, mostly four, spores; spores large, .001′–.0013′ long, .00066′ broad. Under surface of dead or languishing oak leaves.—Peck, 28th Rep. N. Y. State Mus., p. 64.

On *Quercus alba:* Rock Island, Sept. 24, 1667; McLean, Oct. 12, 1848½; Jo Daviess, Sept. 18, 5968; Jersey, Oct. 12, 6276; Jackson, Nov. 5, 2269; Union, Oct. 2, 6541, 6545, Oct. 4, 6565, Oct. 28, 2085, 2186, 2099½. *Q. obtusiloba:* Union, Oct. 2,

6540, Oct. 27, 2064. *Q. macrocarpa:* La Salle, Sept. 17, 1581; Union, Oct. 21, 1917, Oct. 28, 2090, 2095, 2105. *Q. Prinus:* Union (Earle). *Q. imbricaria:* Union, Nov. 1, 2190, 2191. *Q. (nigra ?):* Union, Oct. 4, 6563, 6566, 6577, Oct. 28, 2099, 2100. *Q. coccinea:* Pulaski, Nov. 3, 2224, 2225, Nov. 4, 2241. *Q. tinctoria:* Champaign, Nov. 9, 2376; Union, Oct. 4, 6569, 6568, (6104 ?). *Q. rubra:* McHenry, Aug. 20, 1202, Aug. 27, 1336, Aug. 31, 1390; La Salle, Sept. 17, 1573, Sept. 20, 6255; Rock Island, Sept. 23, 1635; McLean, Oct. 12, 1848, Oct. 18, 1883, Aug. 1, 2368; Stephenson, Sept. 13, 5810; Jersey, Oct. 12, 6275; Union, Oct. 4, 6555, Oct. 25, 2022, Oct. 28, 2081, 2094, Nov. 1, 2192.

This abundant species probably occurs on other kinds of oak in this State besides those mentioned above. Although it is exceedingly variable, specimens from the same host species, even when collected in widely different localities, show a rather surprising agreement in characteristics; and, if varying considerably, it is within much narrower limits than when all the forms occurring on oak are taken into consideration. Thus on *Quercus rubra* the mycelium is confined to the upper surface of the leaf, and the appendages are long, three or four times the diameter, slender, and flexuous. The branches of the appendages are short, and regularly dichotomous. It was this form that Cooke and Peck described as *M. extensa;* and if any of them were worthy of a separate name it would be this one. On *Q. alba* the fungus develops on the under side of the leaf almost as often as on the upper side; the perithecia average larger than on *Q. rubra;* and the appendages are distinctly shorter and more rigid, only once and a half or twice as long as the diameter, while the branching is broader and more irregular, frequently being exceedingly ornate. If these forms stood alone we should be justified in giving them different names, but specimens on *Q. macrocarpa*, *Q. tinctoria*, etc., present many intermediate forms. On *Q. imbricaria*, *nigra*, and *coccinea*, especially when occupying the lower side of the leaf, the appendages are very short, often less than the diameter of the perithecium. This form is *M. abbreviata*, Peck. Some of our specimens agree perfectly with his description, but others show so many intermediate stages between this and the forms with longer

appendages, that it is impossible to maintain specific distinctions. Other short-appendaged forms have been called *M. extensa* var. *brevis* by Peck; and Berkeley (Notices of N. A. Fungi) has referred specimens on oak (probably of this character) to *M. penicillata*, Lév. (*M. alni*, (DC.) Winter). In fact, except that the spores are usually a little larger, it is almost impossible to distinguish some of our specimens on oak, from forms of this latter species; and some specimens of *M. alni* on *Corylus* show appendages so long as to resemble the form of *M. extensa*, Peck. This all goes to show that the two species are very nearly related, and that some forms of each approach the other so closely as to make it difficult to draw the line between them. In the aggregate, however, the forms on oak differ so widely from those of *M. alni*, that they must be considered distinct. Where the fungus occupies both sides of leaves that are woolly or hairy beneath, as in *Q. imbricaria*, etc., there is often considerable difference between perithecia from the upper and lower sides; but where both sides of the leaf are smooth, as in *Q. alba*, very little difference is noticeable.

M. densissima, (Schw.) Peck, cannot be distinguished by its perithecia from the ordinary form on *Q. rubra;* but it presents some peculiarities of the mycelium, which, if constant, would entitle it to specific distinctness. It has not been found in Illinois.

All the other observed forms on *Quercus* must be considered as forming one widely variable species, and it becomes a question of some difficulty to decide under what name it should be known. If it were merely a matter of preference, the choice would easily be in favor of *M. extensa*, C. & P., both from its appropriateness, and because it is so well known. Schweinitz, however, (N. A. Fungi, p. 270) has described a species on oak as follows:—

> *Erysiphe quercinum* L. v. S., sero autumno non rara in foliis quercinis præsertim Bannisteris, Pennsylvania. Hyphasma occupans fere totum folium—expansum candicans, tenuissimum, floccis vix distinctis. Sporangiolis raris, minutissimis, sparsis nigris, Præsertim loco distinguenda species.

This description is not, perhaps, sufficient in itself to enable us to determine positively what specimens he had in

hand, but it contains nothing to contradict the supposition that they belonged to some of the many forms of the species under consideration; and this is so abundant in all parts of the country, that there can be no reasonable doubt that the above supposition is correct.

Accepting this view of the case, priority demands the use of the name given by Schweinitz, rather than the more familiar one by Cooke and Peck; hence we write *M. quercina* and not *M. extensa.*

M. elevata, Burrill.

(Bull. Ill. St. Lab. Nat. Hist., Vol. I., No. 1, p. 58.)

Mostly epiphyllous. Mycelium abundant, persistent, frequently covering the leaves for some time before the appearance of perithecia; perithecia usually few, occasionally abundant, 100–120μ, reticulations large, evident when young; appendages 6–12, sometimes more, 3–4 times as long as the diameter of the perithecium, hyaline, slightly colored at base, smooth, 2–4 times dichotomous, branches short, not swollen, tips at first truncate, divergent, becoming acute and recurved; asci 4–8, ovate, about 33 by 60μ; spores 4–6, mostly 4.

M. elevata, n. sp. Upper sides of leaves of *Catalpa bignonioides.* Mycelium thin, web-like, rather evanescent. Conceptacles .004 in., conspicuously reticulated, raised from the leaf; appendages about twelve, colored at base, often simple, sometimes branched near the base, usually 2 to 4 times dichotomously forked, very long; sporangia four, oval, strongly rostrate.—Burrill, l. c.

On *Catalpa bignonioides:* Jackson, Nov. 5, 2256; Union, Oct. 2, 6537; Champaign, Oct. 17, 6571; Oct. 20, 6577. *Catalpa speciosa:* Union, Sept. 15 (Earle).

This species sometimes involves the foliage of an entire tree, giving it a gray color noticeable at some distance, and causing the leaves to fall prematurely.

The appendages resemble those of *M. vaccinii:* but the branches are not swollen and the tips are usually recurved.

Microsphæra———.

Epiphyllous. Mycelium delicate, sub-persistent; perithecia small, 80–100 μ, reticulations small, indistinct; appendages

6–10, about equaling the diameter of the perithecium, hyaline, delicate, three times dichotomous, branches widely divergent, tips recurved; asci 4–6; spores 5–6, small, narrowly oblong.

On *Scutellaria lateriflora:* Jo Daviess, Sept. 20, 6035.

This may prove to be new. The material at hand is not sufficient for definite determination, or for a full description.

Conidia-bearing mycelium has been collected on the following hosts, not mentioned under any of the above species. In the absence of perithecia it is of course impossible to determine them.

On *Rubus strigosus:* Union, May and June (Earle); Champaign (Burrill). The delicate mycelium is often quite abundant on the leaves and growing fruit, making the berries small and imperfect, or killing them outright.

On *Epilobium* pods: Jo Daviess, Sept. 15, 5902.

On *Cacalia atriplicifolia:* Rock Island, Sept. 23, 1634; Stephenson, Sept. 14, 5864; Union, Oct. 31, 2139.

On *Leptopoda brachypoda:* Union (Earle).

On *Cynoglossum Morisoni:* Jackson, Apr. 19, 4194; Union, Apr. 24, 4263; La Salle, June 16, 5215; Champaign (Burrill).

On *Solanum Carolinense:* Union (Earle).

On *grass:* McLean, July 5 (Seymour); Champaign, common.

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SYSTEMATIC INDEX.

(*Synonyms in Italics.*)

ARTICLE VII. — *Studies of the Food of Fresh-Water Fishes.**
By S. A. FORBES.

FAMILY GADIDÆ.

LOTA MACULOSA, Pennant. BURBOT; LAWYER.

The cod family is represented in Illinois by only a single species, the burbot (*Lota maculosa*), occurring in the interior of Lake Michigan, and making its way at irregular intervals to the shallow waters within the reach of ordinary fishing operations. Since the opening of canals between the Great Lakes and the river systems of the State, occasional specimens have been taken in the Illinois and Mississippi.†

Its predaceous character is too well known to make special description of its alimentary structures necessary. It is reported by Mr. G. Brown Goode‡ to feed upon various small fishes and Crustacea which frequent the bottom, devouring more particularly fishes with habits like its own. It is extremely

* This article is to be considered as a continuation of the studies reported in Volume I. of the Bulletin of the Illinois State Laboratory of Natural History, Nos. 3 and 6, the first published in 1880, and the second in 1883.

The data here presented relate to the fishes of the State of Illinois, and most of them to the lower families of the series. They are derived from collections made by my assistants and myself in various parts of the State at intervals from 1876 to 1887, for the special purpose of ascertaining the principal characters of the food, and the feeding habits of the fishes of our native fauna.

†I have seen a specimen taken from the Mississippi at Canton, Mo., in 1887, and sent to Mr. S. P. Bartlett, one of the State Fish Commissioners of Illinois. One occurred some years ago at Naples, on the Illinois River, and in a letter dated April 10, 1886, Prof. J. Lindahl, of Augustana College, Rock Island, says that three specimens have been taken from the Mississippi River within his knowledge, all small, the largest hardly a foot in length.

‡"The Fishery Industries of the United States," p. 239.

voracious, with a wonderfully distensible stomach; and not only captures the most active fishes, such as the pike, but will eat carrion, and may even swallow stones. It is reported to be nocturnal in habit, and often to secure its prey by stealth.

It is illustrated in our collection by ten examples; five taken in spring and five in November. All but one had eaten fishes, these making eighty-three per cent. of the food of the entire group. One of the spring specimens had taken crayfishes only—*Cambarus propinquus*, the species commonest in the lake. Two others of this lot had likewise eaten crayfishes, fifty per cent. of the food of one and fifteen per cent. that of the other consisting of this same species. The fishes taken, with the exception of one young white-fish (*Coregonus clupeiformis*) and a small unrecognizable residue, were the common perch of the lakes, *Perca lutea.*

FAMILY ESOCIDÆ.

This family is represented within our limits by the European species, *Esox lucius* (the so-called common "pickerel" of the streams and smaller lakes of Illinois), by the noble muskallunge, *Esox nobilior* of Lake Michigan, and by the small grass pickerel, *Esox umbrosus.* No fishes of our waters, unless it be the gars, have become so strictly adapted to a predaceous life, —an adaptation which probably limits them, *nolens volens*, to a living prey.

Esox lucius, Linn. Pike; Pickerel.

Our specimens of this species, thirty-seven in number, of nine different lots, were from various parts of the Illinois River, except a single one from Fourth Lake in northern Illinois.

One had eaten larvæ of dragon flies (twenty per cent.), but the entire food of the remainder consisted only of fishes, these making, consequently, ninety-nine per cent. of the whole. Nine per cent. were not otherwise recognizable. Twenty-one per cent. were sunfishes and black bass—one of the latter the small-mouthed species—and nine per cent. were croppie (Po-

moxys),—eaten however by only one of the specimens. Twenty of the thirty-seven pike had taken gizzard shad (*Dorosoma*), which made forty-six per cent. of the entire food of the species. Cyprinidæ (chiefly *Notropis hudsonius*) were found in two, and three had eaten buffalo fish (*Ictiobus cyprinellus* and *I. bubalus*).

ESOX VERMICULATUS, LeS. BROOK PICKEREL.

This fish — so far as its food structures are concerned a miniature of the preceding—is abundant throughout the State in ponds and lakes and along the borders of streams, especially by the weedy margins of rivers. I have studied the food of eighteen examples, and found it to differ from that of the larger species only as was to be expected from the smaller size of this pickerel, (which rarely reaches a foot in length), and from the character of its favorite haunts.

The specimens selected for examination were from various localities in northern, central, and southern Illinois; represented lakes, rivers, and smaller ponds; and were collected in June, July, and October of different years.

Two had eaten the tadpoles of frogs, and eight had captured fishes,—which made about half of the food of the entire group. Only three of these were recognizable; one a cyprinoid, one a sunfish, and the other (*Gambusia patruelis*) a common top minnow of the southern part of the State.

Aquatic insects formed the next most important element of the food, reaching thirty-five per cent., and eaten by nine of the specimens. The greater part of these were larvæ of Agrion and larger Odonata, only four per cent. being Hexagenia larvæ. One specimen had taken an isopod (Asellus), but no other crustaceans occurred.

The food of this group may consequently be generalized as consisting of the larger aquatic insect larvæ and the smaller fishes in nearly equal ratio, with occasional larvæ of Batrachia.*

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*Five additional specimens of this species, too large to be reckoned examples of the young and yet too small to class as adults had eaten, like the full-grown examples, chiefly fishes and neuropterous larvæ. A specimen only an inch and a half in length had swallowed a fish: one three and a fourth inches long had likewise taken only a

FAMILY SALMONIDÆ.

The common lake trout, the white-fish, and the lake herring, are the representatives of this great family in the waters of Illinois, and occur there only in Lake Michigan. None of the smaller lakes of the State contain the herring, or so-called "cisco," as do some of those of Indiana and Wisconsin.

The food of the trout and adult white-fish having been already studied by the assistants of the United States Fish Commissioner,* I have given them no special attention.†

CORECONUS ARTEDI, LeS. LAKE HERRING.

Gills long, deeply arched; gill chamber consequently capacious but narrow. Gill-rakers rather long and slender, allowing considerable separation of the gills. Only one row on the anterior arch, about thirty-eight in number, projecting almost directly forward, at least equal in length to the corresponding filaments of the gill. The anterior row on the second gill are as stout as those of the first, but only half as long; the second row represented by about ten triangular rudiments at the lower end of the arch. Anterior row gradually shorter on succeeding gills, posterior row longer; the secon drow on the fourth gill opposing a similar series on the pharyngeal arch. Each filament with a double row of fine teeth along the inner edge. No pharyngeal teeth ; pharynx with numerous fine longitudinal ridges which are covered with minute recurved spines. Intestine short and straight, anterior part provided with an immense number of small cœca. Alimentary canal a little shorter than the head and body without the tail.

My specimens of this species available for a study of their food were only five in number, obtained at South Chicago in

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small fish ; and a third, five inches in length, had eaten a young centrarchid. The two others, respectively two and three fourths and four inches long, had filled themselves with larvæ of Agrion and small libellulid larvæ. One had taken, in addition, a minute larval Corixa and a small univalve mollusk.

* See "The Fishery Industries of the United States," pp. 490, 513.

† For a discussion of the first food of the common white-fish, see Bulletin Ill. St. Lab., Nat. Hist., Vol. I., No. 6, pp. 95–109.

October, 1881, and at Chicago in 1885. Numbers of others were examined, but without result, as they had been kept until the food was all digested.

These five specimens had taken only animal food, one of them only Entomostraca—ninety per cent. of these being the common Daphnia of the lakes (*D. hyalina*), and the remainder consisting of a few specimens of Bosmina, *Chydorus sphericus*, and Cyclops. The food of the remaining four was altogether insects of terrestrial origin. In one were recognized great quantities of winged ants (Myrmicidæ), another had eaten only Lepidoptera, and still another winged tipulids (craneflies). In the food of one, numerous specimens of the common squash beetle (*Diabrotica vittata*) were recognized, and a large quantity of undetermined Homoptera. An example of the homopterous insect *Diedrocephala mollipes* was detected in another.

Two small specimens of this species, hardly to be classed as young, respectively two and six inches long, had fed, like most of the adults examined, chiefly upon terrestrial insects, the shortest specimen upon small Diptera (ninety per cent.) and the homopterous insect Typhlocyba. The other example was taken from the stomach of a lake catfish (*Ictalurus lacustris*) from Lake Michigan. It had eaten a variety of terrestrial species, including an ant, several minute Homoptera, *Coriscus ferus*, a species of Amnestus, and examples of the families Staphylinidæ and Anthicidæ.

FAMILY DOROSOMATIDÆ.

DOROSOMA CEPEDIANUM, LeS. GIZZARD SHAD; HICKORY SHAD; MUD SHAD; THREAD HERRING.

This remarkable fish occurs everywhere in the larger streams and in the ponds connected with them, but not in isolated lakes. It is marine in origin, swarming in the coast waters from Delaware to Mexico.

The mouth is toothless except in youth.* The gills are remarkably disposed within a rather small gill chamber. The

* For its juvenile characters and an account of the food of the young, see Bulletin Ill. St. Lab. Nat. Hist., Vol. I., No. 3, pp. 68-70.

dorsal portion of each gill projects far forward in the palatal region, and then turns abruptly backward, forming an acute angle in the roof of the mouth. This course of the arches is necessitated by the large accessory organ upon the fourth branchial arch.* The arches are all provided with numerous short rakers projecting horizontally upon either side, and forming an unusually effective straining apparatus. The intestine is very long and slender and much convoluted, the œsophagus small and long, and the stomach very short and muscular, like the gizzard of a granivorous bird. The small intestine is beset with a multitude of slender cœca, and its mucous surface is everywhere remarkably villose.

The species was represented in our collections by many specimens, but the food was so uniform in character that a prolonged study of it seemed unnecessary, especially as the critical analysis of such large quantities of material, minutely divided and thoroughly intermingled, was a very tedious and time-consuming process.

The adult specimens examined were eleven in number; ten from the Illinois river between Havana and Ottawa, and one from the Pecatonica, in northern Illinois. Eight dates and five localities are represented by them, the former ranging from April to October.

The species has, in general, the habit of swallowing quantities of fine mud, containing, on an average, about twenty per cent. of vegetable *débris*. Occasionally, in the vicinity of distilleries, it feeds, like the buffalo fish, on distillery slops, and sometimes a greater percentage of vegetation occurs mingled with the mud. Traces of animal food were common; but the ratio in most of my specimens was insignificant, averaging only four per cent. of the whole; although in one shad taken in spring in northern Illinois one fourth of the food consisted of Entomostraca (Cypris). Univalve mollusks occurred in one, fragments of Coleoptera in another, and young Corixa in still another; and spiders and water mites were also noted. Five specimens, in all, had taken Entomostraca—four of them

* This accessory organ is correlated by Sagemehl with the limophagous habit of the fishes in which it occurs.—*Morphologisches Jahrbuch*, XII., p. 318.

Cypris, one Cyclops, and two Alona. The vegetable food of the group amounted to thirty-two per cent., eaten by all the specimens. Beside the distillery slops already mentioned, Lemna, Wolffia, various diatoms and other unicellular plants, and occasionally filamentous Algæ, were noted in the food. It is probable that in some situations and at some seasons of the year, Entomostraca would be found a more important element; otherwise one can hardly see the advantage of the excellent branchial strainer borne by this species. The great length of the intestine and the unusual development of the mucous surface are seemingly correlated here, as among the cyprinoids, with the limophagous habit.

In five specimens, two and a half inches in length, the food was intermediate in character between that of the adult and that of the young, about sixty per cent. of it being Algæ, mixed with an abundance of dirt, and the remainder Cladocera (twenty-two per cent.) and insect larvæ — about half of them Chironomus.

A single specimen, five and a fourth inches long, had fed principally on Entomostraca (Bosmina, Daphnia, and Cyclops), with a very few Chironomus larvæ.

FAMILY CLUPEIDÆ.

Only a single species of the herring family occurs in this State — the golden shad, *Clupea chrysochloris*, Raf. — and this not by any means commonly with us. It seems to be strictly predaceous, the three specimens taken by me at Pekin and Peoria in September and October of three different years having eaten only fishes — two of them the gizzard shad (Dorosoma) and the third some undetermined kind. A single small specimen, two and a fourth inches long, had fed wholly upon terrestrial insects, among which were noticed *Triphleps insidiosus*, a species of Typhlocyba, a chalcid (Eurytoma), small Diptera (including Culicidæ and Muscidæ), and some small spiders.

FAMILY HYODONTIDÆ.

HYODON TERGISUS, LeS. MOON EYE; TOOTHED HERRING.

This species, not common in our collections, is represented in these studies by only five specimens, obtained from the Illinois River at Peoria and Havana, on four dates in August and October of two different years (1878 and 1887). Their food consisted wholly of insects (two thirds of them terrestrial) with the exception of a trace of univalve Mollusca. A single one, two and seven eighths inches long, had derived its food about equally from terrestrial and aquatic insects, including Orthoptera, Chironomus larvæ, and *Corixa tumida.*

FAMILY CATOSTOMATIDÆ.

One of the most striking characteristics of the fish fauna of Illinois, and indeed of the Mississippi Valley, is the prominence of the sucker family, which includes within our limits six genera and fifteen recognized species. Several of these are among the most abundant of our larger fishes, and most are very generally distributed.

With reference to the essential characteristics of their food, I find them dividing into three tolerably distinct groups. The first includes the cylindrical suckers (Moxostoma, Catostomus, and the like), in which the pharyngeal bones are heavy, the lower teeth thick and strong, usually with a well-developed grinding surface, and the gill-rakers short, thick, and few. In the second are the deep-bodied suckers, in which the pharyngeal jaws and teeth are well developed, although not as strong as in the cylindrical group, while the gill-rakers are of moderate length and number. The third contains the still deeper-bodied and thinner species, with light pharyngeal jaws and teeth, and long, slender, and more numerous gill-rakers. To this group belong the species commonly placed in the genus Carpiodes. Or, if we arrange the genera in a series, with reference to their food structures, we shall find Placopharynx at one extreme and Carpiodes at the other, the change consisting in a gradual increase in number, length, and effectiveness

of the gill-rakers, correlated with an increase in length of the pharyngeal bones and in the number of their teeth, and a converse diminution in the size and strength of these structures. The intestine also becomes longer and smaller as one passes from the cylindrical suckers to the deep-bodied buffalo and carp.

The data concerning the food of this family here presented are drawn from a study of the alimentary contents of one hundred and nine specimens, collected chiefly from the Illinois and Mississippi Rivers and their immediate tributaries. They indicate, in general, that about one tenth of the food consists of vegetation, taken chiefly by the buffalo fishes (Ictiobus), and in them largely composed of distillery slops. Mollusks and insects appear in nearly equal ratio in the food of the family at large, the former taken much the more generallv by the cylindrical suckers, with heavy pharyngeal jaws and solid teeth, and the latter about equally by all, with the single exception of the stone roller (Hypentelium), whose peculiar haunts and feeding habits explain its departure from the average. On the other hand, the ten per cent. of Entomostraca were eaten chiefly by the deeper-bodied species.

PLACOPHARYNX CARINATUS, Cope.

This species has the general appearance of one of the red horse (Moxostoma), and has possibly been commonly overlooked in our collections, as we have noted it very rarely.

Its branchial apparatus is not noticeably different from that of the following genus, the gill-rakers being short and few, and effective only on the upper part of the arch, the lower arm being, like that of Moxostoma, covered by a ridged pad.

The fish is very remarkably distinguished, however, by the heavy pharyngeal jaws and the thick and strong pharyngeal teeth with conspicuous grinding surface. The latter number about thirty on each pharyngeal, the upper ones minute and useless rudiments, the lower ten very large, occupying about two thirds the length of the arch,—the lower six, in fact, one half of it. It is altogether likely that this apparatus is related to a preference for molluscan food, but the number of specimens available for my examination was too small to verify this supposition.

Two large examples taken from the Illinois at Havana in October, 1887, were found to have eaten similar food. In one, sixty per cent. consisted of small univalve Mollusca (*Valvata carinata* and Amnicola), the remainder being almost wholly insects — chiefly larvæ of water beetles (Hydrophilidæ) and larval Ephemeridæ (largely Cænis). About five per cent. of Lemna occurred in this fish,—probably taken by accident, as the river was covered with a film of duckweed at the time. A few Chironomus larvæ and an Allorchestes were also noted. In the other specimen only five per cent. of the food consisted of mollusks (the same species as before, together with a small. Sphærium). Larval Hydrophilidæ made eighty per cent. of the contents of the intestine, and Ephemeridæ (Cænis) more than ten per cent. Chironomus and other dipterous larvæ, Plumatella, and a little Wolffia, were likewise recorded.

In a third example, only five and a half inches long, the locality of which is not known, the food was chiefly Plumatella, the only other elements being small case-flies (Phryganeidæ), a minute univalve shell (Strepomatidæ), and a few small Chironomus larvæ.

MOXOSTOMA MACROLEPIDOTUM, LeS. COMMON RED HORSE; WHITE SUCKER.

The genus Moxostoma, the commonest and most typical of the cylindrical suckers, is represented in Illinois by three species, two of which, *aureolum* and *macrolepidotum*, occur everywhere in lakes, rivers, and smaller streams. We have encountered *M. carpio* but rarely, and my studies relate only to the two former species.

In *macrolepidotum* the gill-rakers of the anterior row are twenty-five to twenty-seven in number, the upper twenty to twenty-two being elongate, triangular, stout, and crenate within, about three fourths as long as the filaments of the gill; while the lower five or six of this series, all of the second series of the anterior arch, and all of the other rakers of the gills, including the row upon the pharyngeals, have the form of transverse leaf-like plates with crenate edges, projecting in triangular outline a little beyond the margin of the thick gill arch. The gills seem but slightly separable, and the branchial apparatus is coarse and ineffective.

Pharyngeals moderately heavy, the teeth about forty-five on each side, the lower ten thickened and broadened, with smooth terminal edges, but alternately higher and lower in the specimen examined. The other teeth are hooked at the anterior angle, and irregularly crenate on the cutting edge. The intestine is small, one and a fourth times the length of the head and body.

The salient features of the food of *Moxostoma macrolepidotum*, as exhibited by twelve specimens examined, are the abundance of univalve Mollusca and the bivalve Sphærium, the insignificance of the vegetable element, and the absence of Crustacea and the larger and more active insect larvæ. The insect food consisted almost wholly of larvæ of Chironomus and other small mud-inhabiting species.

The molluscan food, taken by eleven of the twelve specimens, amounted to more than half the total, the principal forms represented being Vivipara and Melantho (twenty-two per cent.), Somatogyrus and Amnicola (six per cent.), and the following pulmonates,—Limnea, Physa, and Planorbis. Three of the specimens had eaten Sphærium, but the Unionidæ were only doubtfully represented. The insects—about one third the food—were practically all aquatic, and nearly all dipterous larvæ. Two specimens, however, had taken a small quantity of hydrophilid larvæ, one an Agrion larva, and two others larvæ of Ephemeridæ. The Entomostraca recognized belonged to Alona and Cyclops. The vegetable food consisted of distillery slops, eaten by one of the specimens, with a little Wolffia, Chara, filamentous Algæ, and some miscellaneous matter.

This group of specimens was taken from the Illinois River at Henry, Peoria, Pekin, and Havana, and from Crystal Lake in northern Illinois, at dates ranging from May to November of four different years.

Five additional examples of this genus, the species of which was not determined but which almost certainly belonged to *macrolepidotum*, had eaten a still larger ratio of Mollusca than the preceding group, these making now three fourths of their food,—the greater part Sphærium. Melantho, and Amnicola also occurred, the former making one fourth of the food of the five.

MOXOSTOMA AUREOLUM, LeS. RED HORSE.

This species, less abundant in central Illinois than the preceding, takes almost identical food, so far as one may judge from the six specimens examined by me from Pekin, Peoria, and Crystal Lake in northern Illinois. The food was practically all animal, about one half of it Mollusca — largely Vivipara and Sphærium. The insects were, as before, mostly Chironomus larvæ and pupæ, the only other form worthy of note being smooth, slender, distinctly segmented, footless larvæ with elongate brown heads — very common in the food of fishes, but not yet identified.*

MINYTREMA MELANOPS, Raf. STRIPED SUCKER; SPOTTED MULLET.

In this species, not uncommon throughout the State in suitable streams, the alimentary structures are not essentially different from those of Moxostoma, the pharyngeal teeth being, however, more numerous and more closely set,— about fifty-five in the series, the lower five to ten enlarged, but less so than in Moxostoma, and with the grinding surface less distinctly defined, most of even these largest teeth still presenting a somewhat crenate margin.

So far as indicated by the four specimens examined, the food of this species is similar to that of the preceding, being nearly all Mollusca,—differing, however, in the fact that the thin-shelled bivalve Sphærium had been taken in preference to the thick-shelled univalves. A Cyclops and a larger percentage of Cypris represented the Entomostraca. The small ratio of insects noticed were all Chironomus larvæ.

CATOSTOMUS TERES, Mitch. COMMON SUCKER; WHITE SUCKER; BROOK SUCKER; FINE-SCALED SUCKER.

Abundant northward, occurring rarely in the Illinois as far south as Peoria, and still more rarely in the extreme southern part of the State. Wherever abundant, it inhabits nearly all waters, both lakes and flowing streams. It is common in Lake Michigan.

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* This larva has the superficial characters of the Mycetophilidæ, and was doubtfully assigned to that group by Dr. Williston, in a recent letter to me.

Pharyngeal jaws strong, thick, nearly twice as wide as high ; teeth about thirty-five in number, the lower four or five much thickened, occupying about one fourth the length of the jaw. The crown is expanded transversely to the axis of the jaw, rounded, not crenate or hooked. The crowns of the teeth above the sixth or seventh are hooked and slightly crenate, but less so than in Moxostoma. Compared with that genus, both teeth and jaws constitute a more effective crushing and grinding apparatus.

The system of gill-rakers is similar to that of Moxostoma, but is less effective as a strainer, the anterior row of the first gill being less numerous, shorter, and thicker. These divide into two sets of about equal length, the upper series projecting forward, rather short, triangular, about one third the length of the corresponding filaments, fifteen or sixteen in number, the lower series, five or six, in the form of low lamellar ridges. Rakers of the other gills thick, lamellar, with tubercles on the free edges ; corresponding lamellæ on anterior margin of the pharyngeal jaw.

Alimentary canal about two and a half times the length of the head and body. The alimentary structures in general indicate better adaptation to molluscan food than those of the stone roller, and inferior adaptation to Entomostraca.

The number of specimens examined was too small to make it worth while to report their food, especially as they were evidently under size. The branchial and pharyngeal structures and known habits of the species indicate that its food is not especially different from that of Moxostoma, just discussed, and it will probably be found to consist chiefly of Mollusca and insect larvæ, the former in larger ratio than in Moxostoma, and in smaller ratio than in the species next to follow.

Hypentelium nigricans, LeS. Stone Roller ; Hammer-head.

This curious fish, distinguished both in form and habit from its allies of the family, occurs usually in rapid shallows of clear streams, commonest to the northward. It is taken rarely in lakes.

The square, strong head of this species is related to its mode of life, but the cylindrical body, the large rounded pectoral fin, and relatively high coloration, give the fish the aspect of a darter among the suckers; and its habit of searching for its food among the stones in swift and shallow waters is another point of affinity with that interesting group. Curiously different as are the food and feeding habits of this species when compared with its nearest ally, *Catostomus teres*, the alimentary structures are not remarkably unlike. The pharyngeals are somewhat lighter, the pharyngeal teeth more slender and more prominently cuspidate, and the gill-rakers somewhat stouter, possibly affording a better apparatus for the separation of the relatively large insect larvæ upon which this species chiefly feeds. Its alimentary structures are extremely different, however, from those of the Etheostomatidæ, whose food, haunts, and habits it copies so closely. It is, in short, a molluscan feeder, which has become especially adapted to the search for insect larvæ occuring in rapid water under stones.

The pharyngeals bear about forty teeth on each side, which are unusually high, thin, and acute, all the upper ones with an uncommonly prominent hook or cusp at the internal angle. The six lower teeth are cultrate, without hook or distinct grinding surface, but only two or three are noticeably thickened.

The anterior gill-rakers are short and stout, twenty-five in number, six of them on the horizontal part of the arch. Those of the upper series are thin plates with the base about half the length, and are one third to one half as long as the corresponding filaments. The lower rakers of the series, more prominent than those of *C. teres*, are much like the upper, but shorter, the height scarcely equal to the base. There are five or six tubercles on the upper edge of each. The remaining gill-rakers, similar to those just mentioned, interlock by their tips, which are much more prominent and more tuberculate than those of Moxostoma. The stouter filaments of the strainer are probably related to the larger and more active insect larvæ on which this species feeds.

The intestine is small, considerably convoluted, and about twice the length of the head and body.

The food of six specimens taken in the Fox River and Mackinaw Creek contained no vegetation and but a small ratio of mollusks (Sphærium), but was nearly all aquatic insect larvæ (ninety-two per cent.). The great majority of these were Ephemeridæ, more than half the food consisting of a single form, abundant under stones, belonging to the genus Cænis. A few Chironomus larvæ, taken by all the specimens, some larvæ of Coleoptera, and traces of terrestrial insects were the only other elements.

ERIMYZON SUCETTA, Lac. CREEK FISH; CHUB SUCKER.

Everywhere abundant in streams and lakes, ascending creeks in spring. Occurs in our collections from McHenry to Union county. Rarely taken by us, however, and not represented in the material used for these studies.

Pharyngeal jaws moderately heavy, short for the size of the fish, bearing about sixty teeth, the lower ten filling the lower third of the arch, these moderately enlarged, with inconspicuous grinding surface, the terminal edges being irregularly rounded. The remaining teeth are hooked, the upper ones of the series crenate on the cutting edge.

Anterior gill-rakers thirty-four in number, upper twenty-one short and thick, about one third the length of the gill filaments; tips of the lower members of the series laterally flattened to a paddle shape. About eight of the lower gill-rakers of the anterior series fuse to form a thick ridged pad. Rakers of the remaining arches similar to those of Moxostoma, but more prominent, the tips of the transverse plates projecting further beyond the surface of the arch.

This species presents an ovoid thickening of the palatal region upon either side, which fills the greater part of the branchial chamber, but is less conspicuous than in Ictiobus.

Two young specimens, one and three fourths and three inches respectively, differed but little, in food, from those mentioned on page seventy-two of Bulletin 3 (Vol. I.) of the Illinois State Laboratory of Natural History. The larger one had eaten chiefly the smallest of our Entomostraca (Canthocamptus), with a trace of Chironomus larvæ. The smaller had taken a moderate ratio of Entomostraca (Cypris, Cyclops, and undeter-

mined Lynceidæ), a much larger proportion of Protozoa (especially Difflugia and Arcella), a few Squamella and other rotifers, and unicellular Algæ, including Protococcus, Chroöcoccus, Closterium, and Cosmarium.

GENUS ICTIOBUS. BUFFALO AND RIVER CARP.

In this genus are included only the deeper-bodied suckers with light pharyngeal jaws and relatively long gill-rakers. The species differ, however, in these particulars, and may be arranged in a series exhibiting a progressive lengthening of the gill structures, a lightening of the pharyngeal jaws, and an increase in number and a decrease in size of the pharyngeal teeth. Related to these differences of structure are the inferior importance of mollusks in the food (especially of the thick-shelled univalves), the greater number of insects, the appearance of Entomostraca as an important element, and the considerable percentage of vegetation taken. The insects eaten are well distributed instead of being essentially limited, as in Moxostoma, to dipterous larvæ. In short, correlatively with the greater number and smaller size of the pharyngeal teeth, the weaker jaws, and the greater development of the straining apparatus, in Ictiobus we find the food generalized, and drawn from numerous sources; while in Moxostoma the food and the food prehensile structures are specialized in the direction of a rather close dependence on the smaller mollusks.

The feeding habits of these fishes, like those of all species inhabiting the muddy waters of central Illinois, are very difficult of determination, but several fishermen, and others with unusual opportunities for observation, have reported to me that one or more species of this genus have the peculiar habit of whirling around in shallow water or plowing steadily along, with their heads buried in the mud, and their tails occasionally showing above the surface. These operations have nothing to do with spawning, and it is likely that fishes thus engaged are burrowing for small mollusks and for mud-inhabiting larvæ.

ICTIOBUS BUBALUS, Raf. QUILL-BACK; SMALL-MOUTHED BUFFALO.

This is a very abundant fish in the larger streams and in the lakes and river bottoms, being one of the three species most

commonly shipped from the Illinois and Mississippi under the name of buffalo fish. They all sell as "coarse fish," but from their abundance and their fair character as food, are, on the whole, the most important commercial fishes in our streams.

The gills of this species are very compactly disposed in a rather small branchial chamber, the upper ends of the arches being decurved and the lower elevated so that each gill forms about three fourths of a circle. Ten of the lower rakers of the anterior series are reduced to thickened ridges which extend obliquely across the horizontal portion of the arch. The remainder of this series, thirty-five in number, are flattened, minutely toothed, the central ones about as long as the corresponding filaments of the gill, the others regularly shortened above and below. The other rakers are similar to those of Moxostoma, having the form of toothed triangular plates, with their apices slightly projecting beyond the opposed surfaces of the arches. The interlocking tips are a little more prominent than in Moxostoma, and the whole apparatus is somewhat better developed.

The pharyngeal bones are moderately heavy, triangular in section, about as thick as high; and the teeth, about one hundred and thirty upon each jaw, project directly backwards and act, as in Moxostoma, against a semi-circular rim of cartilage. They are compressed, and more or less crenate on the cutting margin, the upper ones minute, the others gradually thickening downwards so that the lower twelve occupy about one fourth of the length of the arch. The edges of these lower teeth are rounded, not acute.

Seventeen specimens of this species, distributed in seven lots, collected from the central course of the Illinois River and from the Mississippi at Quincy in the years 1880, 1882, and 1887, and in various months from April to October, give the following general view of the food.

In decided contrast to the preceding members of the family, about one fifth of the food consisted of vegetation — taken by sixteen of the fishes—nearly all aquatic, but with an occasional admixture of terrestrial rubbish. The principal vegetable element was a small duckweed (Wolffia) especially abundant in fishes taken from the Illinois during the autumn of 1887,

when it made in some cases as high as ninety-five per cent. The larger duckweed (Lemna), fragments of Ceratophyllum, diatoms, and other unicellular Algæ, are also worthy of mention.

The animal food (eighty per cent.) was fairly well divided between Mollusca, insects, and Crustacea, respectively thirty, twenty-nine, and twenty per cent. Only occasional traces of univalves were noticed (Vivipara and Planorbis); but the thin-shelled bivalve Sphærium was a very important element, taken by seven of the fishes, and reckoned at thirty per cent. of the food of the group. Several individuals had eaten nothing else.

Insect larvæ were very generally taken, and, in fact, occurred in the food of every specimen examined. Chironomus larvæ were reckoned at nearly a fifth of the food, and were found in fourteen out of the seventeen fishes. Neuroptera larvæ, on the other hand, occurred in relatively insignificant number, most of them Ephemeridæ; although a small number of case-worms (Leptocerus) and of dragon-fly larvæ (Agrion) were also noticed. Hydrachnida occurred in the food of one, and Crustacea were eaten by thirteen specimens,—all Entomostraca with the exception of a single small crayfish and an amphipod.

Curiously, the entomostracan eaten most freely by these large fishes was the smallest of the Copepoda — Canthocamptus. In the food of ten specimens taken at Peoria April 16, 1880, and October 6, 1887, this made nineteen per cent. of the food of the entire group. Specimens of Cyclops, Cypris, Pleuroxus, Iliocryptus, Bosmina, and Simocephalus occurred in numbers too small to figure in the ratios. Fresh-water Vermes were almost wholly wanting, only a few Anguillulidæ occurring in the food of one. Eight had eaten Polyzoa, including both Plumatella and Pectinatella. The latter was recognized by its statoblasts only, detected in seven specimens collected in October, 1887, in situations where the gigantic colonies formed by this polyzoan had been earlier very abundant. It is probable, consequently, that these statoblasts, widely dispersed with the death and decay of the translucent mass in which they are developed, had been picked up by accident with the other food.*

* Some notes on the young of this genus, published in the Bulletin of this Laboratory, Vol. I, No. 3, page 73, show that specimens varying

ICTIOBUS CYPRINELLUS, C. & V. RED-MOUTH BUFFALO.

The statements made concerning the abundance, distribution, and commercial value of the preceding species will apply equally well to this. The fishermen report, however, that the quill-back frequents deeper water than the red-mouth. The structures of food prehension differ from those of *bubalus* in the lighter pharyngeal jaws, the greater number and smaller size of the teeth, and the more efficient branchial apparatus. The pharyngeal jaws are relatively thin, the thickness being about one fourth the height. The teeth are about seventy-five in number on each jaw, minute above, gradually but not greatly thickened below, the ten lowest occupying nearly one fifth the length of the jaw. These largest teeth have the cutting edges obtuse, and are slightly hooked within. The remaining teeth are more or less crenate on the cutting edge, each with conspicuous hook or cusp at the inner angle. The posterior edges are also acute.

The gill-rakers are similar to those of the quill-back, but more efficient as a straining apparatus. The longer rakers of the anterior row (seventy-five in number) are fully equal in length to the corresponding filaments, and are armed within with a double row of clusters of minute teeth. Eight or ten of the lower rakers are fused in the form of thick oblique ridges, The tips of the rakers of the other rows project beyond the borders of the arches a distance about equal to the line of attachment to the arch. The pharyngeal enlargements are very conspicuous and thick, nearly filling the pharyngeal cavity.

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in length from seven eighths of an inch to two inches, fed largely upon unicellular Algæ and rotifers, the remainder of their food being chiefly the smallest Entomostraca. I add here the details from two additional specimens. taken in June, from the Illinois River, at Pekin, one three fourths of an inch in length and the other eight tenths. The greater part of the food of these consisted of rotifers, Protozoa, and gelatinous and other unicellular Algæ, a single Bosmina in each being the only entomostracan form determined. The rotifers included Brachionus and Anurea; and among the Protozoa were Actinosphærium, *Arcella vulgaris*, and *A. discoidea*. Closterium was noticed among the Algæ, with numerous gelatinous Algæ related to Protococcus, and a filament of Oscillatoria. Spores of fungi were found in both, and a fragment of vegetation penetrated by a fungus mycelium occurred in one.

This species seems to differ in food from the preceding, especially in the inferior amount of mollusks and the larger ratio of vegetation. The animal food of seventeen specimens collected in seven lots from the Illinois and Mississippi Rivers and the northern lakes in various months from April to October of five different years, was about two thirds the whole, the remaining third consisting largely of Algæ, unicellular and filamentous, and otherwise chiefly of distillery slops (taken by Illinois River specimens) and miscellaneous vegetation of terrestrial origin. This last was occasionally found in quantities sufficient to show that it had been intentionally swallowed, making in one instance the greater part of the food. The molluscan food of these specimens amounted to only three per cent., nearly all Sphærium; the insect food to thirty-three per cent., practically all aquatic, and very largely larvæ of Chironomus (twenty per cent.). The Neuroptera were chiefly Hexagenia larvæ (nine per cent.). Except a single Crangonyx, the Crustacea were all Entomostraca. These occurred in much greater variety than in *cyprinellus*, among them being representatives of Daphnella, Simocephalus, Bosmina, Chydorus, Pleuroxus, Alona, Cypris, Cyclops, and Canthocamptus. Fragments of Plumatella were noticed in a single specimen, Difflugia in two.

Ictiobus urus, Ag. Black Buffalo; Mongrel Buffalo; Big-mouthed Buffalo; Chuckle-head.

This species occurs commonly with the preceding, but less abundantly. Said by fishermen to frequent shallower water.

With respect to food, it closely resembles *cyprinellus*, our seventeen specimens, well distributed as to date and place, having taken almost identical ratios of animal and vegetable food — sixty-seven per cent. and thirty-three per cent. respectively. Twelve per cent. were mollusks,— nearly all Sphærium, as before. The large ratio of insect food (about forty-two per cent.) was more than half Chironomus larvæ, most of the remainder being Hexagenia larvæ, taken, however, by only one of the specimens. The Crustacea (thirteen per cent.) were practically all Entomostraca, fragments of a young crayfish appearing in only a single specimen.

Among the vegetable elements, distillery slops (eaten by three of the specimens) were the most important (twenty-one per cent.). The rather insignificant amount of aquatic vegetation (six per cent.) was distributed as usual among a number of the lower plants, chiefly duckweeds and the unicellular Algæ.

ICTIOBUS CYPRINUS, LeS. RIVER CARP; CARP SUCKER.

Under this specific head I include, for the purposes of this paper, all the so-called species of river carp sometimes separated under the genus Carpiodes, and hitherto described under some eight specific names. This form is abundant in the great rivers of the State and in their larger tributaries, and also in Lake Michigan and the smaller lakes of northern Illinois. It is extremely common in the lakes and ponds of the river bottoms, but occurs in running water in smaller numbers than the other species of its genus.

In its structures of food prehension it exhibits an extreme development and a correlative degradation of branchial apparatus and pharyngeal structures respectively. The gills are remarkably compacted, the upper and lower ends nearly meeting when the mouth is closed. The pharyngeal protuberances are enormous, almost filling the branchial cavity. Anterior gill-rakers in two series, as usual, the upper about sixty-seven in number on three fourths of the arch, the longest a little longer than the corresponding filaments. The lower part of the gill with about ten thick, papillar, coherent ridges extending downward a distance equal to the length of the filaments of the same vicinity. The longer rakers have each two closely alternating rows of tubercles on the inner edge, roughened with extremely minute denticles. Inner surface of the arch with transverse tuberculate ridges springing from the bases of the rakers of the gill, and terminating inwardly in slight projections representing the posterior row of rakers. The other arches are similarly tuberculate and ridged, and the whole apparatus closely embraces the pharyngeal thickenings. Pharyngeal bones very thin and brittle, less than a millimeter thick in a fish ten inches long, the thickness one seventh the height to the base of the teeth. The latter about two hundred, minute above, gradually increasing downwards, but not much thick-

ened or elongate, about thirty on the lower fourth of the arch. Crowns emarginate or doubly emarginate, with the inner angle similarly produced, forming a hook or cusp. Intestine very slender, four times as long as head and body in the specimen examined.

Nineteen examples of the species, representing thirteen dates and localities, from April to October, and from 1877 to 1887, collected from Crystal Lake in northern Illinois, from the lakes of the Ohio near Cairo, and from the Illinois River at Ottawa, Peoria, and Havana, show that the native carp differs from the other species of Ictiobus chiefly in the inferior amount of vegetation eaten, in the greater quantity of mud mingled with the food, in the absence of the larger insect larvæ, and in the lack of univalve Mollusca. It resembles closely *Ictiobus cyprinellus*, but from this differs also with respect to the vegetation taken, and in its filthy feeding habits. The vegetable food was only eight per cent., mostly Wolffia, and that eaten by only two of the specimens. A few diatoms were mingled with the mud in three, and miscellaneous aquatic vegetation occurred in five. Mollusks made about a fourth of the food,—all the thin-shelled Sphærium. Insects averaged about one third, the greater part Chironomus larvæ. Neuroptera were eaten by only four of the specimens, and contributed only two per cent. to the food, case-worms (Phryganeidæ) being the only forms identified. Entomostraca made nearly a fourth, distributed through a considerable list, which included *Simocephalus americanus*, Bosmina, Chydorus, Alona, Cypris, Cyclops, and Canthocamptus. No Vermes or Polyzoa were observed, but occasional Protozoa were noticed, especially Centropyxis and Difflugia.

Looking now at the food of the family, as exhibited by the one hundred and seven specimens discussed, representing, as they do, five genera and eleven species, we conclude that the sucker family is essentially carnivorous, the vegetable food amounting to only eight per cent. of the whole, and no element of this being especially prominent. The smaller mollusks are the most important single class, the ratio of these being forty-one per cent., about three fourths of them Sphærium. The large quantity of aquatic insects (one third of

them Chironomus and a fourth ephemerid larvæ), the relative insignificance of Crustacea (about ten per cent.,— nearly all Entomostraca), and the practical absence of Vermes and Protozoa are the remaining salient features of the food characters of this family.

FAMILY SILURIDÆ.

The family of catfishes taken together is nearly omnivorous in habit, and their alimentary structures have a correspondingly generalized character. The capacious mouth, wide œsophagus, and short broad stomach, admit objects of relatively large size and of nearly every shape; the jaws, each armed with a broad pad of fine sharp teeth, are well calculated to grasp and hold soft bodies as well as hard; the gill-rakers are of average number and development; and the pharyngeal jaws — broad, stout arches below and oval pads above, with thin opposed surfaces covered with minute, pointed denticles — serve fairly well to crush the crusts of insects and the shells of the smaller mollusks and to squeeze and grind the vegetable objects which appear in the food. The use made of the jaws in tearing mollusks from their shells, as described further on, is probably the most peculiar feeding practice of these animals; and the indifference of several of the species to the past history or the present condition of their food, distinguishes them as the only habitual scavengers among our common fishes.

The family is a very abundant and characteristic one in this region. It ranges in size from the smaller species of Noturus, only an inch or two in length, to monsters more than two hundred pounds in weight; and inhabits every kind of water from the greatest rivers of the continent to small temporary ponds of surface water, where its presence is the standing wonder of the fisherman and the naturalist.

In Illinois we have three genera and twelve species of these fishes, as at present classified, none of them unfit for food except the smallest ones, and two or three of them the equals of any river fish.

My studies of their food were based upon one hundred and twenty specimens, belonging mostly to five species of Ictalurus and Noturus. The data are especially deficient with respect to the food of the largest lake and river species.

ICTALURUS FURCATUS, C. & V. CHANNEL CAT; FORK-TAILED CAT; WHITE FULTON.

This is the catfish *par excellence*, and is the best food fish of its family. It occurs only in the deeper water of the larger streams. It is common in the Mississippi and the Ohio, although much less so than the following species, but is taken rather rarely in the Illinois, where it is often called the "Mississippi cat." It is never found in lakes and ponds, and feeds, according to the reports of fishermen, almost exclusively upon other fishes. A single specimen taken at Quincy Oct. 25, 1887, had eaten fishes only.

The gill apparatus is better developed than in Amiurus, but is nevertheless very incomplete. The anterior arch has only one row of rakers, eleven in number below the angle, four or five above. These are longest near the upper end of the lower part of the gill, where they are about half the length of the corresponding filaments. The other gills have similar but shorter rakers, the third and fourth a double row of about equal length. None of the rakers are toothed or tuberculate. The pharyngeals, both superior and inferior, are similar to those of Amiurus, but relatively smaller.

ICTALURUS PUNCTATUS, Raf. BLUE FULTON; SPOTTED CAT; FIDDLER; SWITCH TAIL.

An abundant species in the larger rivers, much commoner than the preceding, but not quite so good for food, smaller, ranging more freely, and clearly a more general feeder, although its alimentary structures are not noticeably different.

The gill-rakers of the anterior arch are a trifle shorter, the longer ones being about one third the length of the corresponding filaments, and the pharyngeal structures seemingly a little heavier.

Forty-three specimens of this species were taken from the Illinois River at Peoria, Pekin, and Havana, and from the Mississippi River, near Quincy. Their dates of capture represent the spring, summer, and autumn months of the years 1878, 1880, and 1887.

About a fourth of the food consisted of vegetable matter, much of it miscellaneous and accidental, but chiefly Algæ — Cladophora being the most abundant form. This and other filamentous Algæ made a large part of the food of several fishes taken in October, 1878 and 1887, three having eaten nothing else. Fragments of Potamogeton were taken by other October specimens, making twenty per cent. of the food of three. The fact that the floating Lemna occurred but rarely, and then in the smallest quantity, is evidence that these cat-fishes are strictly bottom feeders. A single specimen had fed on still-house slops, as shown by the considerable amount of meal in its alimentary contents.

A dead rat, pieces of ham, and other animal *débris* attest the easy-going appetite of this thrifty species.

Fragments of fishes were found in eleven examples of this group,— commonly, however, in pieces so large as to make it certain that they were derived from those already dead. Occasionally, as in examples taken in August, 1887, from the Mississippi River, fishes probably taken alive composed the whole of the food. The species were not identifiable.

Molluscan food was a decidedly important element, being found in fifteen of the fishes and amounting to fifteen per cent. of the whole. Several specimens had taken little or nothing else, —notably six secured at Havana in September, 1887, and one at Peoria in October of the same year. The Mollusca were about equally divided between gasteropods and lamellibranchs, the former largely Melantho and Vivipara, the latter usually Unio or Anodonta.

Notwithstanding the number of bivalves eaten by these fishes, no fragment of a shell was ever found in their stomachs, but the bodies of the animals had invariably been torn from the shell while yet living — as shown both by the fresh condition of the recently ingested specimens and likewise by the fact that the adductor muscles were scarcely ever present in the frag-

ments. Indeed in only a single instance had the posterior adductor been torn loose. The Unionidæ were usually large and thin — probably in most cases Anodonta.

I have been repeatedly assured by fishermen that the catfish seizes the foot of the mollusk while the latter is extended from the shell, and tears the animal loose by vigorously jerking and rubbing it about. One intelligent fisherman informed me that he was often first notified of the presence of catfishes in his seine, in making a haul, by seeing the fragments of clams floating on the surface, disgorged by the struggling captives.

Still more interesting and curious was the fact that the univalve Mollusca found in the stomachs of these fishes were almost invariably naked, the more or less mutilated bodies having only the opercles attached. How these fishes manage to separate mollusks like Melantho and Vivipara from the shell, I am scarcely able to imagine, unless they have the power to crack the shells in their jaws as a boy would nuts, and then to pick out the body afterward. Certainly the shells are not swallowed, either whole or broken.

The number of mollusks sometimes taken by a single catfish is surprising. As high as one hundred and twenty bodies and opercles of Melantho and Vivipara were counted in a spotted catfish taken at Havana in September of last year.

Insects were, however, the principal food of the specimens studied, making forty-four per cent. of all, eaten by twenty-eight of the specimens; five, in fact, had eaten nothing else, and nine others had taken ninety per cent. or more of insects. These were mostly aquatic, although now and then a fish had filled itself with terrestrial specimens. About half the insects were Neuroptera, nearly equally dragon-fly larvæ and larvæ of Ephemeridæ; but Hexagenia larvæ were rarely recognized. Chironomus larvæ made thirteen per cent. of the food, and were so frequently taken with the sand tubes they inhabit as to make it certain that they were commonly obtained from the bottom. Leeches appeared in the food of three of the specimens, and Gordius in one. Fragments of Plumatella were noticed in two, and a fresh water sponge likewise in two.

Four immature examples of this species, ranging from two and a half to four inches in length, had fed almost wholly

upon insects, a few specimens of *Allorchestes dentata* and Daphnia being the only other items. Eggs and young of Hexagenia and other ephemerids composed the greater part of the food, Chironomus larvæ amounting to about one half as much.*

ICTALURUS NATALIS, LeS. YELLOW CAT.

This species occurs everywhere throughout Illinois, but less abundantly than *nebulosus*, and usually in larger streams. It has not been taken by us from ponds and lakes except where these were immediately connected with rivers subject to overflow.

The alimentary structures of this species closely resemble those of *I. nebulosus*, described under the next head. Twelve specimens were collected from the Illinois River at Peoria, the Fox River at McHenry, and from one of the smaller lakes in northern Illinois, in the months of May, August, October, and November of 1878, 1880, and 1887.

The food was wholly animal with the exception of a trace of duckweeds (Lemna and Wolffia) taken by a single specimen. The scavenger habit of the species was shown by the food of the Fox River specimen, three fourths of which consisted of the remnants of a dead cat. Fishes made a larger ratio of the food than in the preceding species, amounting to about one third, most of them apparently taken alive. One, however, a sucker, was represented only by the stomach and intestines, doubtless picked up near a fish boat. The gizzard shad, certain Cyprinidæ, and undetermined suckers (Catostomatidæ) were recognized, four of the twelve specimens having fed wholly or almost wholly upon them. The molluscan food of these specimens was insignificant, no bivalve mollusks having been taken by them and only a few Vivipara and Melantho, amounting in all to five per cent. While insects had been eaten by four of the specimens and reached a ratio of thirty per cent., they were practically all Hexagenia larvæ, taken in October, 1878 and 1887. On the other hand, seventeen per cent. of the food was catfishes, taken by four of the specimens in May and August.

* A hint of the winter food is given by six specimens received from the Illinois River at Havana, February, 1888, all of which had fed only upon Chironomus larvæ or larvæ of Agrion.

Seven immature examples, from two to three and a half inches long, had fed chiefly upon Entomostraca, which made about one half the food. Among these, Daphnia, *Simocephalus americanus*, Acroperus, *Macrothrix laticornis*, Cyclops, and Cypris were determined. One fourth the food consisted of the univalve Physa, and one fifth of it of insect larvæ, chiefly ephemerids and Chironomus. A little Wolffia and other aquatic vegetation likewise occurred.

ICTALURUS NEBULOSUS, LeS. BULL-HEAD; HORNED-POUT.

This superabundant species occurs in all waters and in all parts of the state, but frequents by preference ponds and muddy streams. It grows to a larger size in the rivers than elsewhere, and has many marked varieties. Its feeding habits are apparently essentially the same in all situations.

Gill-rakers fourteen in number on the anterior gill, in one row, thick, stout, not toothed, at the angle of the arch about half as long as the filaments, shortening rapidly above and below. Second gill also with a single row, shorter than those of the first; succeeding gill with two rows each of still shorter rakers, the posterior row shorter than the anterior; a smaller row upon the pharyngeal arch. The upper pharyngeals are large and broad oval pads, with convex surfaces paved with close-set, minute, sharp teeth, and act against the broad lower pharyngeals, which are similarly armed. Intestine to head and body as 1.2 to 1.

Thirty-six specimens were collected for a study of the food, — at Normal, Peoria, Pekin, and Havana, in Central Illinois; and from the Fox River and several of the small lakes in the northern part of the state. The collections were made in May, July, August, September, and October, of four different years.

The vegetable food nearly equaled that of *I. punctatus*, and was taken by seven of the specimens. One had eaten distillery slops, and in the food of the others were found Ceratophyllum, Potamogeton, Chara, and various Algæ.

Fishes made one fifth of the food,— taken however by only two of the specimens, which had eaten nothing else. One of the fishes was a perch and the other a sunfish (Centrarchidæ).

Mollusks made one fifth of the entire amount of the food, — more than one half of them Sphærium. This genus made nearly all the food of a large group taken from the Illinois River at Pekin in September, 1882, and also of two other specimens taken in the Illinois River at Peoria in October, 1887. Univalves were rarely present, amounting to only two per cent. of the food, taken however by eight of the specimens. These included the usual forms —Valvata, Melantho, and Amnicola, together with two or three specimens of Physa. Examples of Pisidium were rarely noted, and two had eaten Unios.

Nearly a fourth of the food was insects, mostly aquatic, and the larger part of them larvæ of Diptera — especially Chironomus and Corethra. Seven per cent. of Neuroptera larvæ (Hexagenia, Libellulidæ, and Phryganeidæ), together with a miscellaneous assortment of terrestrial species, complete the account of the insect food.

The Crustaceans (thirteen per cent.) were nearly all crayfish, traces of Diaptomus, Leptodora, Chydorus, etc., appearing, however, in here and there a specimen, and the little amphipod *Allorchestes dentata*, appearing in three. A leech and a nematoid worm occurred, each in one.

It will be seen that the food of this species was very widely distributed, being composed about equally of fishes, mollusks, aquatic insects, and vegetable structures, with a very considerable ratio (thirteen per cent.) of crustaceans added.

Two smaller specimens, two and three and a half inches respectively, had fed chiefly on ephemerid and Chironomus larvæ, small crayfish, and Asellus. To these were added *Corixa tumida*, Cyclops, Daphnia, filaments of Spongilla, Chydorus, *Scapholeberis mucronatus*, a few Diatoms, and traces of filamentous Algæ.

Ictalurus marmoratus, Holbrook. Marbled Cat.

This species is scarcely more than a deep-water variety of the common bull-head (*I. nebulosus*), distinguished only by the color. It occurs in the larger rivers of the State and their immediate tributaries, but nowhere, so far as I know, in stagnant waters. Our thirteen specimens were all from Peoria and Havana, taken in August, October, and November of 1878 and 1887.

The food of this species as represented by these thirteen specimens, is unusually simple for a catfish, consisting chiefly of bivalve mollusks, larvæ of Chironomus and Hexagenia, distillery slops, and accidental rubbish. Fishes are conspicuous by their absence, only a single specimen exhibiting any trace of them.

Sphærium and Unio made about a fourth of the food, and aquatic insect larvæ amounted to one half (Hexagenia thirty-five per cent. and Chironomus fourteen). A hydrophilid and a few terrestrial insects, a few specimens of Vivipara and a Physa, sialid larvæ (taken by two), slender leeches eaten by five, and a trace of Potamogeton in one, are the minor elements of this record. One of the specimens, taken in November, had eaten eighteen leeches, which made one fourth of its food. It will be noticed that three fourths of the food consisted of bivalve mollusks and insect larvæ.

LEPTOPS OLIVARIS, Raf. MUD CAT; YELLOW CAT; MORGAN CAT.

Common in the deeper waters of the larger streams. Obtained by us only from the Illinois, Wabash, and Ohio.

This is one of the largest of the river catfishes, repulsive in appearance, but above the average as food. It is reported by fishermen to feed only upon animal food — chiefly fishes — and such was the case with the two specimens examined from collections made at Quincy in August, 1887. These had fed upon the common river sunfish (Lepomis), several cyprinoids, and an Amiurus four inches long.

NOTURUS GYRINUS, Mitch.

This little catfish, the most abundant of the small species of the family, occurs throughout Illinois, but has been confined in our collections mostly to lakes, rivers, and large creeks. It is not by any means restricted to rocky situations, but seems rather to prefer the muddy parts of both the rivers and lakes in which it occurs,

Thirteen specimens were secured at Pekin and Peoria, from Clear Lake in Kentucky, and from the Fox River in McHenry county. Their food was wholly animal, with the exception of a trace of Algæ found in two. This group

had eaten practically nothing but Crustacea, nearly all Amphipoda (Allorchestes) and Isopoda (Asellus), the former eaten by nine, and the latter by two — both together making forty-seven per cent. of the entire food. As might be supposed from the small size of these specimens, Entomostraca were apparent in the food, although in moderate numbers (five per cent.). The forms recognized were Simocephalus, Chydorus, Pleuroxus, Alona, Cypris, Candona, Cyclops, and Canthocamptus. A planarian worm was noted in one, and specimens of Difflugia in another. A single example had eaten a small fish. Most of the insects were Chironomus larvæ (twenty-five per cent.), case-worms, and larvæ of day flies (twelve per cent.).

Comparing the principal genera of this family, as represented by the one hundred and twenty specimens examined, we find that the larger deep-water species from the great rivers of the State are apparently ichthyophagous; that the relatively minute stone cats feed on the smaller insect larvæ and the medium sized Crustacea; that the spotted cat is essentially insectivorous; that among the bull-heads the yellow cat eats the largest percentage of fishes and the marbled cat the smallest; that the latter feeds more generally upon Unio than any of the other species; and that mollusks at large make about one sixth of the food of the group of species which feeds upon them.

FAMILY AMIIDÆ.

AMIA CALVA, Linn. DOG FISH; MUD FISH; GRINDLE.

This species is very abundant throughout the State in the lakes and larger streams, and also common in ponds of southern Illinois. Not commonly eaten, but often caught for sport.

The food of twenty-one specimens taken from northern, central, and southern Illinois, in April, May, June, August, September, and October, was wholly animal, about one third of it fishes, among which were recognized some undetermined cyprinoids and a small buffalo fish (Ictiobus). The other important elements were mollusks — about one fourth — and crustaceans (forty per cent.), insects being represented by an insignificant ratio (two per cent.). Even the usually abundant Chironomus

and ephemerid larvæ had been eaten by only one or two specimens each. The mollusks were more than two thirds Sphærium, the remainder being Vivipara and Planorbis. The Crustacea were chiefly crayfish, among them *Cambarus virilis* and *obesus*. Besides these, I noticed Crangonyx, Allorchestes, and Asellus, Cyclops and a few Cladocera (*Simocephalus americanus*, *Scapholeberis mucronatus*, and Chydorus).

FAMILY LEPIDOSTEIDÆ.

A half dozen of the river gars *Lepidosteus platystomus* and *L. osseus* had eaten nothing but fishes, including the hickory shad (Dorosoma), black bass (Micropterus), and some minnows (Cyprinidæ).

FAMILY POLYODONTIDÆ.

Polyodon spathula, Wall. Shovel-fish; Paddle-fish; Spoon-bill Cat; Duck-bill Cat.

This remarkable and most interesting fish, the most notable inhabitant of our waters, occurs abundantly in the Illinois, Mississippi, and Ohio, but not elsewhere within our limits. It has a more or less distinct habit of migration, being much the most abundant in spring, although taken sparingly throughout the remainder of the year. It is a gigantic species, reaching a weight of thirty pounds and upwards, and a length of six feet or more, including the paddle. It is now quite generally dressed for the market, and sold at the same rate as catfish.

It has an alimentary apparatus not less remarkable than its other characters. The broad blade-like snout, the enormous mouth and equally large gill slits, the efficient branchial strainer, and the peculiar structure of the intestine,—all indicate a peculiar alimentary regimen and unusual feeding habits. Both the upper and lower jaws of the young are provided with small, acute teeth—the upper with a band upon the vomer and palatines, besides a row on the maxillaries, and the lower with a longitudinal row extending nearly its full length—but the jaws of the adult are toothless and smooth.

This fish depends, therefore, entirely upon the very remarkable straining apparatus borne by the gills, the immense oral opening, and the equally free provison for the exit of water from the gill chamber, enabling it to pass vast quantities of water through its branchial apparatus. The gills are very elongate, each having the form, when the mouth is closed, of a slender *U* with the sides parallel and closely approximated, the lower arm, however, extending somewhat further forward than the upper. Each gill bears throughout its whole length a double series of very long, fine, numerous, and slender rakers, the two rows separated by a membranous partition borne upon the anterior surface of the arch,—this partition a little higher than the rows of rakers, and slightly thickened on the internal edge, so as to enclose the tips of the rakers when the parts of the apparatus are approximated. These rakers average fully twice the length of the corresponding gill filaments, and numbered, on the first gill of a specimen about one and a half feet long, five hundred and sixty rakers in the anterior series. A half row of similar rakers is borne by the fifth branchial arch, corresponding to the inferior pharyngeal bones of most fishes. The individual rakers are toothless, smooth, cartilaginous, and nearly naked, the filaments covered by a thin epithelium, thickened at the tip. Interlocking as these do when the branchial apparatus is extended, they form a strainer, sufficient to arrest the smallest living forms above the Protozoa. There are no pharyngeal jaws or teeth, nor is there any apparatus of mastication elsewhere.

In the absence of any raptatorial teeth or crushing apparatus in its large and feeble jaws or in its throat, it is certain that this species cannot feed upon fishes or mollusks; and the character of the intestine makes it very probable that it never purposely swallows mud or takes a large percentage of vegetable food. On the other hand, its enormous mouth, and the remarkable straining apparatus in its branchial cavity give it access to the immense stores of minute insect and crustacean life most commonly reserved for young fishes; while its structures are likewise evidently adapted to the larger soft-bodied insects and insect larvæ.

The use of the paddle-like snout is as yet a matter of conjecture, slightly assisted, perhaps, by a knowledge of the princi-

pal features of the food. The relatively minute size of the objects on which it feeds, the absence of mud from its intestine, and its seemingly positive preference for animal food, indicate that it is not only able to gather large quantities of very minute objects among the weeds and from the muddy bottom without filling itself with mud, but that it can separate the Entomostraca from the Algæ among which they swim. I cannot see how this is done unless its paddle be used to stir up the weeds in its advance, as it swims along, thus driving up the animal forms within reach of its branchial strainer, while the mud and vegetation settle out of its way.

What is the meaning of the minute and evanescent teeth on the jaws of Polyodon, I am unable to surmise, but judge that they can only be accounted for by reference to primitive conditions of life of which the present habits of the fish give us no hint.

Eight specimens obtained from Peoria, Pekin, and Henry on the Illinois, from the Ohio River at Cairo, and from the Mississippi at Quincy, in six different years, will probably suffice to give a fair general idea of the food, taken in connection with suggestions made above, based on a study of the structures of alimentation.

The vegetable elements of the food were eaten by four of the specimens, and amounted to only seven per cent. It is to be noted, however, that one of the specimens taken at Quincy had derived thirty per cent. of its food from a species of Nostoc, while another, taken at Peoria in May, had found about one fifth of its food among vegetable objects. A little Potamogeton, some filamentous algæ and diatoms, together with a small amount of terrestrial rubbish, were the elements recorded.

Fishes and mollusks were without representation in the alimentary contents of these specimens; while insects and crustaceans made by far the larger part of the food,— the former taken by all the specimens, and in nearly twice the ratio of the latter. The minor items of this class were Corethra larvæ (twelve per cent.) and Chironomus larvæ (five per cent.). Larvæ of Neuroptera made one half the food, and were eaten by six of the specimens,— Hexagenia larvæ alone amounting to forty-seven per cent. A few case-worms (Phryganeidæ),

dragon-fly larvæ (Libellulidæ and Agrion), and Cænis larvæ, with a few Corisas, aquatic beetles (Coptotomus), and chance terrestrial insects, were the remaining items of this class.

The crustaceans were all Entomostraca, with the exception of the amphipod *Allorchestes dentata*, noted in two specimens. Five of the specimens had eaten Entomostraca, one of them ninety per cent., and another eighty,—the remaining ratios being thirty-five, thirty, and twenty. Water mites (Hydrachnida) were noticed in a single specimen, leeches also in one, and Plumatella in another. The smaller Crustacea were so numerous that no attempt was made to exhaust the possible determinations; but in some cursory examination of this material the following forms were observed: *Daphnia pulex*, Bosmina, Chydorus, Eurycercus, Leptodora, Cypris, Cyclops, and Canthocamptus.

To the comparative anatomist, Polyodon is peculiarly notable as among the oldest of fishes, distinguished, when compared with higher species, by the persistence of juvenile characters; and similarly we find that the most remarkable feature of its food is one which it shares with young fishes in general. This is, however, a simulated correlation, the food habit not being due to a persistence of youthful structures of alimentation, but to a remarkable specialization of the apparatus of food prehension. It must consequently be correlated with a superabundant supply of minute animal life when and where these structures originated, or, at least, when they took their present form; and taken together with the great size of this fish and its out-worn dental furniture, seemingly indicates a radical change in the feeding habits of the species, and a capacity for adaptation to new circumstances which possibly accounts for its long survival.

FOOD OF SMALLER FAMILIES.*

	Lota maculosa	Esox lucius	Esox vermiculatus	Summary of Esox	Coregonus artedi	Dorosoma cepedianum	Clupea chrysochloris	Hyodon tergisus	Amia calva	Lepidosteus platystomus	Lepidosteus osseus	Summary of Lepidosteus	Polyodon spathula
NUMBER OF SPECIMENS EXAMINED.	10	37	19	56	5	11	4	8	12	2	4	6	8
KINDS OF FOOD.	RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.												
ANIMAL FOOD	1.00	1.00	1.00	1.00	1.00	.04	1.00	1.00	1.00	1.00	1.00	1.00	.93
I. BATRACHIA (tadpoles)	....	....	.13	.07	....	....	....	....	....	....	....	....	....
II. FISHES	.83	.98	.52	.75	....	....	1.00	....	.33	.67	1.00	.83	....
Cycloid	....	.09	.11	.10	....	....	....	....	....	....	....	....	....
Acanthopteri	.62	.23	.11	.17	....	....	....	....	.09	+	....	+	....
Perca lutea	.62	....	....	....	....	....	....	....	....	....	....	....	....
Centrarchinæ	....	.21	.11	.16	....	....	....	....	....	....	....	....	....
Micropterus	....	.03	....	.02	....	....	....	....	....	....	....	....	....
Pomoxys	....	.69	....	.04	....	....	....	....	....	....	....	....	....
Gambusia patruelis	....	....	.04	.02	....	....	....	....	....	....	....	....	....
Coregonus	.10	....	....	....	....	....	....	....	....	....	....	....	....
Dorosoma cepedianum	....	.46	....	.23	....	....	.67	....	....	.50	.25	.38	....
Hyodon	....	.05	....	.03	....	....	....	....	....	....	....	....	....
Cyprinidæ	....	.03	.09	.06	....	....	....	....	.04	+	.20	.10	....
Catostomatidæ	....	.03	....	.01	....	....	....	....	+	....	....	....	....
III. MOLLUSCA	....	....	+	+	....	+	....	+	.24	....	....	....	....
1. *Univalves*	....	....	+	+	....	+	....	+	.07	....	....	....	....
Vivipara	....	....	....	....	....	....	....	....	.06	....	....	....	....
2. *Bivalves* (Sphærium)	....	....	....	....	....	+	....	....	.17	....	....	....	....
IV. INSECTA	....	.02	.35	.18	.50	+	+	1.00	.02	....	....	....	.59
Terrestrial	....	....	....	....	.50	+	....	.64	....	....	....	....	.01
Aquatic	....	.02	.29	.15	....	+	....	.36	.02	....	....	....	.58
1. *Hymenoptera*	....	....	....	....	.11	....	....	+	....	....	....	....	....
Myrmicidæ	....	....	....	....	.11	....	....	....	....	....	....	....	....
2. *Lepidoptera*	....	....	....	....	.13	....	....	+	....	....	....	....	....
3. *Diptera*	....	....	....	....	.13	....	....	+	.01	....	....	....	.18
Terrestrial	....	....	....	....	.13	....	....	+	....	....	....	....	+
Tipulidæ	....	....	....	....	.13	....	....	+	....	....	....	....	....
Aquatic larvæ	....	....	....	....	....	....	....	....	.01	....	....	....	.18
Corethra	....	....	....	....	....	....	....	....	....	....	....	....	.12
Chironomidæ	....	....	....	....	....	....	....	....	.01	....	....	....	.05
4. *Coleoptera*	...	....	....	....	.02	+	....	+	....	....	....	....	.02
Terrestrial	....	....	....	....	.02	+	....	+	....	....	....	....	+
Chrysomelidæ	....	....	....	....	.02	....	....	+	....	....	....	....	....
Aquatic	....	....	....	....	....	....	....	+	....	....	....	....	.01
Dytiscidæ	....	....	....	....	....	....	....	+	....	....	....	....	.01
Hydrophilidæ	....	....	....	....	....	....	....	+	....	....	....	....	....
5. *Hemiptera*	....	....	+	+	.11	+	....	+	+	....	....	....	+

* The sign + indicates a ratio not estimated.

FOOD OF SMALLER FAMILIES.—*Continued.*

	Lota maculosa	Esox lucius	Esox vermiculatus	Summary of Esox	Coregonus artedi	Dorosoma cepedianum	Clupea chrysochloris	Hyodon tergisus	Amia calva	Lepidosteus platystomus	Lepidosteus osseus	Summary of Lepidosteus	Polyodon spathula
NUMBER OF SPECIMENS EXAMINED.	10	37	19	56	5	11	4	8	12	2	4	6	8
KINDS OF FOOD.	RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.												
Terrestrial	....	....	....	....	.11	....	....	+	....	....	....	....	....
Homoptera	....	....	....	....	.11	....	....	+	....	....	....	....	....
Aquatic	....	....	+	+	....	+	....	+	+	....	....	....	+
Corisa	....	....	+	+	....	+	....	+	+	....	....	....	+
6. *Orthoptera* (Tettix)	....	....	....	....	....	....	....	+	....	....	....	....	....
7. *Neuroptera* (larvæ)	....	.02	.29	.15	....	....	....	.66	.01	....	....	....	.51
Phryganeidæ	....	....	....	....	....	....	....	....	....	....	....	....	.02
Odonata	....	.02	.25	.13	....	....	....	....	.01	....	....	....	.02
Libellulinæ	....	.02	.02	.02	....	....	....	....	.01	....	....	....	+
Agrion	....	....	.15	.07	....	....	....	....	....	....	....	....	+
Ephemeridæ	....	....	.04	.02	....	....	....	.66	+	....	....	....	.47
Hexagenia	....	....	.04	.02	....	....	....	.33	....	....	....	....	.47
V. ARACHNIDA	....	....	....	....	....	+	....	+	....	....	....	....	.01
VI. CRUSTACEA	.17	....	+	+	.50	.04	....	+	.41	.33	....	.17	.33
1. *Decapoda* (Cambarus)	....	....	....	....	....	....	....	....	.38	.33	....	.17	....
2. *Amphipoda*	....	....	....	....	....	....	....	....	.01	....	....	....	+
3. *Isopoda* (Asellus)	....	....	+	+	....	....	....	....	+	....	....	....	....
ENTOMOSTRACA	....	....	....	....	.50	.04	....	+	.02	....	....	....	.33
4. *Cladocera*	....	....	....	....	+	+	....	+	+	....	....	....	+
5. *Ostracoda* (Cypris)	....	....	....	....	....	.04	....	....	....	....	....	....	+
6. *Copepoda*	....	....	....	....	+	+	....	....	.02	....	....	....	.08
VII. VERMES (leech)	....	....	....	....	....	....	....	....	....	....	....	....	+
VIII. BRYOZOA (Plumatella)	....	....	....	....	....	....	....	....	....	....	....	....	+
IX. PROTOZOA (Difflugia)	....	....	....	....	....	+	....	....	....	....	....	....	....
VEGETABLE FOOD	....	....	+	+	....	.32	....	+	+	....	....	....	.07
Miscellaneous	....	....	....	....	....	.16	....	+	....	....	....	....	+
Terrestrial	....	....	+	+	....	....	....	....	....	....	....	....	.01
Aquatic	....	....	....	....	....	+	....	....	+	....	....	....	.06
Lemna	....	....	....	....	....	+	....	....	....	....	....	....	....
Wolffia	....	....	....	....	....	+	....	....	....	....	....	....	....
Algæ	....	....	....	....	....	+	....	....	....	....	....	....	.05
Nostoc	....	....	....	....	....	....	....	....	....	....	....	....	.05
Distillery Slops	....	....	....	....	....	.16	....	....	....	....	....	....	....
MUD AND SAND	....	....	....	....	....	.64	....	....	....	....	....	....	....

FOOD OF CATOSTOMATIDÆ.

	Placopharynx carinatus	Moxostoma aureolum	Moxostoma macrolepidotum	Summary of Moxostoma*	Minytrema melanops	Hypentelium nigricans	Catostomus teres	Carpiodes cyprinus	Ictiobus bubalus	Ictiobus urus	Ictiobus cyprinella	Summary of Ictiobus	Summary of Catostomatidæ
NUMBER OF SPECIMENS EXAMINED.	2	6	12	23*	4	5	3	19	17	17	17	51	107
KINDS OF FOOD.	RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.												
ANIMAL FOOD	.95	.97	.87	.95	1.00	1.00	.94	.83	.80	.67	.65	.71	.90
I. FISHES	....	....	....	....	....	+	....	....	....	....	....	....	+
II. MOLLUSCA	.32	.49	.55	.60	.87	.10	.42	.24	.30	.12	.03	.15	.41
1. *Univalves*	+	.16	.40	.27	.01	....	.12	+	+	+	+	+	.06
Viviparidæ	....	.13	.22	.20	....	....	....	....	+	....	....	+	.03
Somatogyrus	....	....	.06	.02	....	....	....	....	....	....	....	....	.01
Limnæa	....	....	.10	.03	....	....	....	....	....	....	....	....	.01
2. *Bivalves*	+	.33	.15	33	.86	.10	.30	.24	.30	.14	.02	.15	.30
Sphærium	+	.17	.15	.28	.86	.10	.30	.24	.30	.14	.02	.15	.29
Unionidæ	....	....	+	+	....	....	....	....	....	....	....	....	+
III. Insecta	.63	.48	.32	.35	.10	.90	.03	.32	.29	.42	.33	.35	.37
Terrestrial	....	....	+	+	....	+	....	....	.01	+	+	+	+
Aquatic	.63	.46	.31	.34	.10	.90	.03	.32	.28	.42	.36	.37	.37
1. *Diptera*	.03	.46	.30	.33	.10	.04	.03	.30	.19	.25	.24	.23	.17
Terrestrial	....	....	+	+	....	....	....	....	....	+	....	+	+
Aquatic larvæ	.03	.46	.30	.33	.10	.04	.03	.30	.19	.25	.24	.24	.17
Chironomidæ	.03	.30	.15	.15	.10	.04	.03	.22	.19	.23	.20	.22	.12
2. *Coleoptera*	.50	....	+	+	....	.13	....	....	.02	+	+	+	.10
Terrestrial	....	....	+	+	....	.01	....	....	.01	+	....	+	+
Aquatic larvæ	.50	....	+	+	....	.12	....	....	.01	....	+	+	.10
Hydrophilidæ	.50	....	+	+	....	....	....	....	.01	....	....	+	.09
3. *Hemiptera*	....	....	....	....	....	....	....	....	....	.01	.01	.01	+
Corisa	....	....	....	....	....	....	....	....	....	.01	.01	.01	+
4. *Neuroptera*	.10	....	.01	.01	....	.72	....	.02	.08	.16	.11	.11	.10
Terrestrial	....	....	....	....	....	....	....	....	....	+	....	+	+
Aquatic larvæ	.10	....	.01	.01	....	.72	....	.02	.08	.16	.11	.11	.10
Phryganeidæ	....	....	....	....	....	....	....	.01	.01	....	....	+	+
Sialidæ	....	....	....	....	....	....	....	....	....	....	.01	+	+
Odonata	....	....	+	+	....	....	....	....	.01	.01	....	.01	+
Ephemeridæ	.10	....	.01	.01	....	72	....	....	.06	.15	.10	.10	.10
Cænis	....	....	....	....	....	.53	....	....	....	....	....	....	.05
Hexagenia	....	....	....	....	....	.12	....	....	....	.14	.09	.08	.02
IV. ARACHNIDA	....	....	....	....	....	....	.02	....	+	+	+	+	+
V. CRUSTACEA	+	....	+	+	.03	....	.30	.23	.20	.13	.29	.21	.11

* Includes five specimens of undetermined species.

FOOD OF CATOSTOMATIDÆ.—*Continued.*

	Placopharynx carinatus	Moxostoma aureolum	Moxostoma macrolepidotum	Summary of Moxostoma*	Minytrema melanops	Hypentelium nigricans	Catostomus teres	Carpiodes cyprinus	Ictiobus bubalus	Ictiobus urus	Ictiobus cyprinella	Summary of Ictiobus	Summary of Catostomatidæ
NUMBER OF SPECIMENS EXAMINED.	2	6	12	23*	4	5	3	19	17	17	17	51	107
KINDS OF FOOD.	RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.												
1. *Decapoda* (Cambarus)	....	....	....	....	....	....	....	....	....	+	....	+	+
2. *Amphipoda*	+	....	....	....	....	....	....	+	.01	....	+	01	.01
ENTOMOSTRACA	....	....	+	+	.03	....	.30	.23	.19	.13	.29	.20	.10
3. *Cladocera*	....	....	+	+	....	....	.30	.03	+	.05	.08	.05	.04
Daphnella	....	....	....	....	....	....	....	....	....	....	+	+	+
Daphniidæ	....	....	....	....	...	....	....	.03	+	.05	+	.02	.01
Lynceidæ	....	....	+	+	....	....	.30	+	+	+	+	+	.03
4. *Ostracoda* (Cypridæ)	....	....	....	....	.03	....	+	.04	+	.02	.05	.03	.02
5, *Copepoda*	....	....	+	+	+	....	+	.08	.19	.04	+	.08	.03
VI. VERMES	....	....	....	....	....	....	.02	....	+	....	+	+	+
Rotifera	....	....	....	....	....	....	+	....	....	....	....	....	+
VII. POLYZOA	+	....	....	....	....	....	....	....	.01	....	+	+	+
VIII. PROTOZOA (Rhizopoda)	....	....	....	....	....	....	.15	+	....	+	+	+	.01
VEGETABLE FOOD.	.05	.03	.10	.04	....	+	.06	.08	.20	.33	.35	.29	.08
Seeds	....	....	....	....	....	....	.02	....	.02	+	.09	.04	.01
Aquatic	.05	.01	.07	.02	....	+	.04	.08	.15	.06	.17	.12	.05
Lemna	.03	....	....	....	....	....	....	....	+	+	+	+	.01
Wolffia	.01	....	.10	+	....	....	....	.05	.11	+	....	.03	.01
Algæ	....	....	+	+	....	....	.04	+	+	.01	.15	.05	.01
Filamentous	....	....	+	+	....	....	.02	....	+	+	.05	.02	.01
Diatoms	....	....	....	....	....	....	+	+	+	+	+	+	+
Distillery Slops	....	....	.03	.01	....	....	....	....	....	.21	.09	.10	.02
MUD	....	+	.03	.01	+	....	....	.09	....	+	+	+	.02

* Includes five specimens of undetermined species.

FOOD OF SILURIDÆ.

	Ictalurus furcatus	Ictalurus punctatus	Amiurus natalis	Amiurus nebulosus.	Amiurus marmoratus	Summary of Amiurus	Leptops olivaris	Noturus gyrinus	Summary of Siluridæ
NUMBER OF SPECIMENS EXAMINED.	1	43	12	36	13	61	2	13	120
KINDS OF FOOD.	RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.								
ANIMAL FOOD	1.00	.75	1.00	.77	.93	.90	1.00	.98	.96
Dead animal matter	....	.02	.13	....	.14	.09	....	....	.02
I. FISHES	1.00	.10	.34	.20	.01	.18	1.00	+	.44
Percidæ	....	....	....	.20	....	.06	.43	....	.16
Lepomis	....	....	....	....	....	....	.43	....	.14
Cyprinidæ	....	....	.04	....	....	.01	.30	....	.10
Catostomatidæ	....	....	.17	....	....	.06	....	....	.01
Amiurus	....	....	....	....	....	....	.20	....	.07
II. MOLLUSCA	....	.15	.05	.19	.26	.16	....	....	.04
1. *Univalves*	....	.08	.05	.02	.01	.02	....	....	01
Vivipara	....	.01	.04	....	+	.01	....	....	.01
Melantho	....	.03	+	.01	....	.01	....	....	+
2. *Bivalves*	....	.07	....	.17	.25	.14	....	....	.03
Sphærium	....	....	....	.13	.12	.08	....	....	.02
Unionidæ	....	....	....	.04	.13	.06	....	....	.01
III. INSECTA	....	.44	.30	.28	.50	.36	....	.46	.26
Terrestrial	....	.07	....	+	+	+	....	.01	.01
Aquatic	....	.36	.30	.27	.50	.36	....	.41	.24
1. *Hymenoptera*	....	+	....	....	....	....	....	....	+
2. *Lepidoptera*	....	+	....	....	....	....	....	....	+
3. *Diptera*	....	.13	....	.20	.14	.11	....	.27	.12
Terrestrial	....	+	....	....	....	....	....	.01	+
Aquatic	....	.13	....	.20	.14	.11	....	.26	.12
Corethra	....	....	....	.09	+	.03	....	....	.01
Chironomus	....	.13	....	.10	.14	.08	....	.25	.11
4. *Coleoptera*	....	+	....	+	.01	.01	....	.02	.01
Terrestrial	....	+	....	+	+	+	....	....	+
Carabidæ	....	+	....	+	...	+	....	....	+
Staphylinidæ	....	+	....	....	....	....	....	....	+
Aquatic larvæ	....	+	....	+	.01	.01	....	.02	.01
Dytiscidæ	....	+	....	+	....	+	....	....	....
Hydrophilidæ	....	....	....	....	.01	.01	....	....	+
5. *Hemiptera*	....	.01	....	+	....	+	....	....	+
Terrestrial	....	+	....	....	....	....	....	....	+
Aquatic	....	.01	....	+	....	+	....	....	+
Corixa	....	+	....	+	....	+	....	....	+
6. *Orthoptera*	...	.05	....	....	+	+	....	....	.01

FOOD OF SILURIDÆ.—*Continued.*

NUMBER OF SPECIMENS EXAMINED.	Ictalurus furcatus	Ictalurus punctatus	Amiurus natalis	Amiurus nebulosus.	Amiurus marmoratus	Summary of Amiurus	Leptops olivaris	Noturus gyrinus	Summary of Siluridæ
	1	43	12	36	13	61	2	13	120
KINDS OF FOOD.	RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.								
Acrididæ	....	.04	....	....	....	....	....	....	.01
7. *Neuroptera* (larvæ)	....	.23	.30	.07	.35	.24	....	.12	.10
Phryganeidæ	....	.01	....	+	....	+	....	.02	.01
Sialidæ	....	+	....	.01	+	+	....	....	+
Odonata	....	.08	....	.02	....	.01	....	....	.01
Libellulinæ	....	.07	....	.02	....	.01	....	....	.01
Agrioninæ	...	01	....	....	....	....	....	....	+
Ephemeridæ	....	.09	.30	.04	.35	.23	....	.10	.08
Hexagenia	....	.03	.30	.04	.35	.23	....	....	.05
IV. ARACHNIDA	....	+	.01	....	+	+	....	....	+
V. CRUSTACEA	....	.03	.17	.13	....	.10	....	.52	.19
1. *Decapoda* (Cambarus)	....	.03	.17	.12	....	.10	....	....	.02
2. *Amphipoda* (Allorchestes)	....	+	....	.01	....	+	....	.25	.08
3. *Isopoda* (Asellus)	....	....	....	....	....	....	....	.22	.07
ENTOMOSTRACA	....	....	....	+	....	+	....	.05	.02
4. *Cladocera*	....	....	....	+	....	+	....	.02	.01
5. *Ostracoda*	....	....	....	....	....	....	....	+	+
6. *Copepoda*	....	....	....	+	....	+	....	.03	.01
VI. VERMES	....	.01	....	.01	.02	.01	....	+	.01
Hirudinei	....	.01	....	.01	.02	.01	....	....	.01
Nematodes	....	+	....	+	....	+	....	....	+
VII. BRYOZOA (Plumatella)	....	+	....	....	....	....	....	....	+
VIII. PORIFERA (Spongilla)	....	+	....	....	....	....	....	....	+
IX. PROTOZOA (Difflugia)	....	....	....	....	....	....	....	+	+
VEGETABLE FOOD	....	.25	+	.23	.07	.10	....	.02	.04
Miscellaneous	....	.01	....	.05	+	.02	....	.01	+
Aquatic	....	.23	+	.16	+	.06	....	.01	.03
Lemna	....	+	+	....	....	+	....	....	+
Wolffia	....	....	+	....	....	+	....	....	+
Potamogeton	....	.06	....	.01	+	.01	....	....	+
Algæ	....	.16	....	.02	....	.01	....	.01	.02
Distillery slops	....	.01	....	+	.07	.02	....	....	.01
MUD	....	....	....	+	....	+	....	....	+

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ARTICLE VIII.—*On the Food Relations of Fresh-Water Fishes: a Summary and Discussion.*—By S. A. FORBES.

The principal object of the research reported in the series of papers* of which this is the concluding number, is to determine more precisely than has hitherto been done the relations to nature of the various genera and families of the fishes of an interior region. This purpose has led especially to a study of the *food relations* of the groups, for through these, chiefly, fishes exert their influence on the outer world, and are themselves impressed in turn; and thus have appeared a number of subordinate considerations having a bearing, more or less direct, on the main intention of the study.

An examination of the special relations of their food and feeding structures gives us clues, not only to the present significance of fishes, but also to their past effect on life at large, showing how they must have modified the course of evolution; and the occasional occurrence in a fish of food prehensile structures out of present relation to its feeding habits, may throw light on the history of its group, indicating conditions of existence once normal to it but now outgrown. Evidence of similar application may also be obtained by a comparison of the food of the young and of the adult.

The feeding apparatus exhibits some of the most significant examples of correlation of structure, important to an acquaintance with the course of development in fishes, but not comprehensible without a knowledge of the food for whose appropria-

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* Published at intervals from 1877 to 1888, in the first and second volumes of the Bulletin of this Laboratory, as follows: "The Food of Illinois Fishes" (Vol. I., No. 2, pp. 71–89), "The Food of Fishes" (No. 3, pp. 18–65), "On the Food of Young Fishes" (No. 3, pp. 66–79), "The Food of the Smaller Fresh-Water Fishes" (No. 6, pp. 65–94), The First Food of the Common White-fish, (No. 6, pp. 95–109), and "Studies of the Food of Fresh-Water Fishes" (Vol II., Art. VII., pp. 433–473).

tion it is adapted. I need hardly recall the fact that the defensive apparatus of one species may have its explanation only in the raptatorial structures of another.

We shall find also in a study of the food evidence of the indirect but powerful action of a number of external conditions which take effect only through the food relation, and are incomprehensible or perhaps unnoticed unless this is understood —conditions of climate, season, locality, and the like; and especially may we hope for this when we remember that the distribution and abundance of a species may be determined, not so much by ordinary conditions, as by those prevailing at critical intervals, periods of stress, when a slight advantage or a trivial disability may have prolonged and multiplied effects. As the range of a plant is often limited, not by the average temperature of the year, but by the extremes of cold or heat, so the existence of an animal may be decided by the presence or absence of some structural modification adapted to carry it safely through a single brief period of unusual scarcity or of extraordinary competition.

That the study here set forth should give us details not to be otherwise obtained of the struggle for existence among fishes themselves, goes without saying; and that it may thus explain some peculiarities of distribution, seems also probable. I have thought it not impossible that by taking into account all the data collected, and the mass of related facts, structural, biological, and other, that materials might be found bearing on the interesting question of the precedence in time and the relative evolutionary importance of desire and effort on the one hand and structural aptitudes on the other.

Among the purely practical results to be anticipated, are a more accurate knowledge of the conditions favorable to the growth and multiplication of the more important species; the ability to judge intelligently of the fitness of any body of water to sustain a greater number or a more profitable assemblage of fishes than those occurring there spontaneously; guidance as to the new elements of food and circumstance which it will be necessary to supply to insure the successful introduction into any lake or stream of a fish not native there; and a clear recognition of the fact that intelligent fish culture must take into

account the necessities of the species whose increase is desired, through all ages and all stages of their growth, at every season of the year, and under all varieties of condition likely to arise. We should derive, in short, from these and similar researches, a body of full, precise, and significant knowledge to take the place of the guess-work and empiricism upon which we must otherwise depend as the basis of our efforts to maintain the supply of food and the incitement to healthful recreation afforded by the waters of the State.

As a contribution to the general subject, I present herewith a summary account of the food of twelve hundred and twenty-one fishes obtained from the waters of Illinois at intervals from 1876 to 1887, and in various months from April to November. These fishes belonged to eighty-seven species of sixty-three genera and twenty-five families. They were derived from waters of every description, ranging from Lake Michigan to weedy stagnant ponds and temporary pools, and from the Mississippi and Ohio Rivers to the muddy prairie creeks, and the rocky rivulets of the hilly portions of the State. Nine hundred and fourteen of the examples studied were practically adult, so far as the purposes of this investigation are concerned, the remaining three hundred and seven being young, in the first stage of their food and feeding habits. More than half these young belonged to a single species,— the common lake white-fish,— but the remainder were well distributed.

I have arranged the matter under the following general heads: (1) a summary statement of the food, so made as to exhibit (*a*) the kinds and relative importance of the principal competitions among fishes and (*b*) the relative value to the principal species of fishes of the major elements of their food; (2) a brief account of the food of the young; (3) an examination of the permanency and definiteness of distinctions with respect to food, between different species, and also between higher groups; (4) a review of the structures of fishes related to food prehension and to their feeding habits; and, finally, (5) a classified list of the objects detected in the food of fishes, with a statement, against each object, of the species feeding on it and the number of specimens in which it was found.

THE FOOD OF ADULT FISHES.

An analysis of our facts made with reference to the kinds of fishes eating each of the principal articles in the dietary of the class and showing the relative importance of these elements in the food of the various species, will exhibit the competitions of fishes for food more clearly and precisely than my earlier discussions, and also the nature and the energy of the restraints imposed by fishes on the multiplication of their principal food species.

PISCIVOROUS FISHES.

The principal fish-eaters among our species — those whose average food in the adult stage consists of seventy-five per cent. or more of fishes — are the burbot[1], the pike-perch[2] or wall-eyed pike, the common pike[3] or "pickerel," the large-mouthed black bass,[4] the channel cat,[5] the mud cat,[6] and the gars.[7] Possibly also the golden shad[8] will be found strictly ichthyophagous, this being the case with the four specimens which I studied.

Those which take fishes in moderate amount — the ratios ranging in my specimens from twenty-five to sixty-five per cent. — are the war-mouth (Chænobryttus), the blue-cheeked sunfish,[9] the grass pickerel,[10] the dog-fish,[11] the spotted cat,[12] and the small miller's thumb[13]. The white[14] and striped bass,[15] the common perch,[16] the remaining sunfishes (those with smaller mouths), the rock bass,[17] and the croppie,[18] take but few fishes, these making, according to my observations, not less than five nor more than twenty-five per cent. of their food.

Those which capture living fishes, to a trivial extent, at most, are the white perch or sheepshead,[19] the gizzard

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[1] Lota maculosa. [2] Stizostedion vitreum. [3] Esox lucius. [4] Micropterus salmoides. [5] Ictalurus furcatus. [6] Leptops olivaris. [7] Lepidosteus. [8] Clupea chrysochloris. [9] Lepomis cyanellus. [10] Esox vermiculatus. [11] Amia calva. [12] Ictalurus punctatus. [13] Uranidea richardsonii. [14] Roccus chrysops. [15] Roccus interruptus. [16] Perca lutea. [17] Ambloplites rupestris. [18] Pomoxys. [19] Aplodinotus.

shad,[1] the suckers,[2] and the shovel fish[3] among the larger species; the darters,[4] the brook silversides,[5] the stickleback,[6] the mud minnows,[7] the top minnows,[8] the stonecats,[9] and the common minnows[10] generally, among the smaller kinds.

Our eight specimens of the toothed herring[11] had taken no fishes whatever; while our nineteen examples of the pirate perch[12] had eaten only two per cent.

Rough-scaled fishes with spiny fins (Acanthopteri) were eaten by the miller's thumb, the common pike, the wall-eyed pike, the large-mouthed black bass, the croppies, the dog-fish, the common perch, the burbot, the bull-head,[13] the common sunfish *(Lepomis pallidus)*, the small-mouthed black bass,[14] the grass pickerel, the gar, and the mud cat (Leptops). Among these, the common perch and the sunfishes[15] were most frequently taken — doubtless owing to their greater relative abundance — the perch occuring in the food of the burbot, the large-mouthed black bass, and the bull-head; and sunfishes in both species of the wall-eyed pike, the common pike, the gars, pickerel, bull-heads, and mud cat. Black bass were taken from the common pike (Esox), the wall-eyed pike (Stizostedion), and the gar. Croppie and rock bass I recognized only in the pike. Even the catfishes (Siluridæ) with their stout, sharp, and poisoned spines, were more frequently eaten than would be expected,— taken, according to my notes, by the wall-eyed pike, both black bass, and the mud-cat (the latter a fellow species of the family).

The soft-finned fishes were not very much more abundant, on the whole, in the stomachs of other species than were those with ctenoid scales, spiny fins, and other defensive structures,— an unexpected circumstance which I cannot at present explain, because I do not know whether it expresses a normal and fixed relation, or whether it may not be due to human interference. It will be shown, however, under another head, that even when the primitive order of nature prevails, the relative numbers of soft-finned and predaceous fishes vary greatly from year to year under the influence of varying circumstances.

[1] Dorosoma cepedianum. [2] Catostomatidæ. [3] Polyodon spathula. [4] Etheostomatinæ. [5] Labidesthes sicculus. [6] Eucalia inconstans. [7] Umbra limi. [8] Zygonectes. [9] Noturus. [10] Cyprinidæ. [11] Hyodon tergisus. [12] Aphredoderus sayanus. [13] Amiurus nebulosus. [14] Micropterus dolomiei. [15] Centrarchidæ.

Only the catfishes seem to have acquired defensive structures equal to their protection, the predatory apparatus of the carnivorous fishes having elsewhere outrun in development the protective equipment of the best-defended species.

Among the soft-finned fishes the most valuable as food for other kinds is the gizzard shad (Dorosoma),— this single fish being about twice as common in adults as all the minnow family taken together. It made forty per cent. of the food of the wall-eyed pike; a third that of the black bass; nearly half that of the common pike or "pickerel"; two thirds that of the four specimens of golden shad examined; and a third of the food of the gars. The only other fishes in whose stomachs it was recognized were the yellow cat *(Amiurus natalis)* and the young white bass *(Roccus)*. It thus seems to be the especial food of the large game fishes and other particularly predaceous kinds.

The minnow family (Cyprinidæ) are in our waters especially appropriated to the support of half-grown game fishes, and the smaller carnivorous species. They were found in the wall-eyed pike, the perch, the black bass, the blue-cheeked sunfish, the croppie, the pirate perch, the pike, the little pickerel,[1] the chub minnow,[2] the yellow cat, the mud cat, the dog-fish, and the gar.

Suckers (Catostomatidæ) I determined only from the pike, the sheepshead, the blue-cheeked sunfish, the yellow cat, and the dog-fish (Amia). Buffalo[3] and carp[4] occurred in the pike, the dog-fish, and the above sunfish.

MOLLUSK EATERS.

The ponds and muddy streams of the Mississippi Valley are the native home of mollusks in remarkable variety and number, and these form a feature of the fauna of the region not less conspicuous and important than its characteristic and leading groups of fishes. We might, therefore, reasonably expect to find these dominant groups connected by the food relation; and consistently with this expectation, we observe that the sheepshead, the cat-fishes, the suckers, and the dog-fish find an impor-

[1] Esox vermiculatus. [2] Semotilus. [3] Ictiobus. [4] Carpiodes.

tant part of their food in the molluscan forms abundant in the waters which they themselves most frequent. The class as a whole makes about one fourth of the food of the dog-fish and the sheepshead,— taking the latter as they come, half-grown and adults together,—about half that of the cylindrical suckers,—rising to sixty per cent. in the red horse,[1]— and a considerable ratio (fourteen to sixteen per cent.) of the food of the perch, the common catfishes (Amiurus and Ictalurus). the small-mouthed sunfishes, the top minnows, and the shiner (Notemigonus). Notwithstanding the abundance of the fresh water clams or river mussels (Unio and Anodonta), only a single river fish is especially adapted to their destruction, viz., the white perch or sheepshead; and this species derives, on the whole, a larger part of its food from univalve than from bivalve mollusks, the former being eaten especially by half-grown specimens, and the latter being the chief dependence of the adults.

The ability of the catfishes to tear the less powerful clams from their shells has been especially discussed in another paper* containing the details of the food of the family. Even the very young Unios were rarely encountered in the food of fishes, my notes recording their presence in only three sunfishes, a brook silversides, and a perch. Large clams were eaten freely by the full-grown sheepshead—whose enormous and powerful pharyngeal jaws with their solid pavement teeth are adapted to crushing the shells of mollusks—and by the bull-heads (Amiurus), especially the marbled cat.[2] The small and thin-shelled Sphæriums are much more frequent objects in the food of mollusk-eating fishes than are the Unios. This genus alone made twenty-nine per cent. of the food of our one hundred and seven specimens of the sucker family, and nineteen per cent. of that of a dozen dog-fishes. Among the suckers it was eaten greedily by both the cylindrical and the deep-bodied species, although somewhat more freely by the former. Even the river carp,[3] with its weak pharyngeal jaws and delicate teeth, finds these sufficient to crush the shells of Sphærium, and our nineteen specimens had obtained about

* Bull. Ill. St. Lab. Nat. Hist., Vol. II., pp. 457, 458.

[1] Moxostoma. [2] Amiurus marmoratus. [3] Carpiodes.

one fourth of their food from this genus. Besides the above families, smaller quantities of the bivalve mollusks occurred in the food of one of the sunfishes *(Lepomis pallidus)* and — doubtless by accident only — in the gizzard shad.

The gasteropod mollusks (snails of various descriptions) were more abundant than bivalve forms in the sheepshead and the sunfishes and all the smaller fishes which feed upon Mollusca, but less abundant in the suckers and the catfishes. In the sheepshead they made one fifth of the food of the twenty-five specimens examined, but the greater part of these had not yet passed the insectivorous stage, this being much longer continued in the sheepshead than in many other fishes. A few of these univalve Mollusca occurred in the food of the common perch and in certain species of sunfishes, especially in the superabundant bream or pumpkin-seed. They made fifteen per cent. of the food of the minute top minnows, and occurred in smaller quantities among the darters, the grass pickerel, the mud minnows, and the cyprinoids. The heavier river snails, Vivipara and Melantho, were eaten especially by the cylindrical suckers, and the catfishes. The delicate pond snails (Succinea, Limnæa, and Physa) were taken chiefly by the smaller mollusk-eating fishes,—a few of them also by the catfishes and the suckers.

Further particulars concerning the molluscan food may be obtained by the interested reader from the list of food elements at the end of this article.

INSECTIVOROUS SPECIES.

It is from the class of insects that adult fishes derive the most important portion of their food, this class furnishing, for example, forty per cent. of the food of all the adults which I examined.

The principal insectivorous fishes are the smaller species, whose size and food structures, when adult, unfit them for the capture of Entomostraca, and yet do not bring them within reach of fishes or Mollusca. Some of these fishes have peculiar habits which render them especially dependent upon insect life,— the little minnow Phenacobius, for example, which, according to my studies, makes nearly all its food from insects (ninety-eight per cent.) found under stones in running

water. Next are the pirate perch, Aphredoderus (ninety-one per cent.), then the darters (eighty-seven per cent.), the croppies (seventy-three per cent.), half-grown sheepshead (seventy-one per cent.), the shovel fish (fifty-nine per cent.), the chub minnow (fifty-six per cent.), the black warrior sunfish (Chænobryttus) and the brook silversides (each fifty-four per cent.), and the rock bass and the cyprinoid genus Notropis, (each fifty-two per cent.)

Those which take few insects or none are mostly the mud-feeders and the ichthyophagous species, Amia (the dog-fish) being the only exception noted to this general statement. Thus we find insects wholly or nearly absent from the adult dietary of the burbot, the pike, the gar, the black bass, the wall-eyed pike, and the great river catfish, and from that of the hickory shad[1] and the mud-eating minnows (the shiner, the fat-head,[2] etc.). It is to be noted, however, that the larger fishes all go through an insectivorous stage, whether their food when adult be almost wholly other fishes, as with the gar and the pike, or mollusks, as with the sheepshead. The mud-feeders, however, seem not to pass through this stage, but to adopt the limophagous habit as soon as they cease to depend upon Entomostraca.

Terrestrial insects, dropping into the water accidentally or swept in by rains, are evidently diligently sought and largely depended upon by several species, such as the pirate perch, the brook minnow, the top minnows or killifishes (cyprinodonts), the toothed herring and several cyprinoids (Semotilus, Pimephales, and Notropis).

Among aquatic insects, minute slender dipterous larvæ, belonging mostly to Chironomus, Corethra, and allied genera, are of remarkable importance, making, in fact, nearly one tenth of the food of all the fishes studied. They are most abundant in Phenacobius and Etheostoma, which genera have become especially adapted to the search for these insect forms in shallow rocky streams. Next I found them most generally in the pirate perch, the brook silversides, and the stickleback, in which they averaged forty-five per cent. They amounted to about one third the food of fishes as large and important as the red

[1] Dorosoma. [2] Pimephales.

horse and the river carp, and made nearly one fourth that of fifty-one buffalo fishes. They appear further in considerable quantity in the food of a number of the minnow family (Notropis, Pimephales, etc.), which habitually frequent the swift water of stony streams, but were curiously deficient in the small collection of miller's thumbs (Cottidæ) which hunt for food in similar situations. The sunfishes eat but few of this important group, the average of the family being only six per cent.

Larvæ of aquatic beetles, notwithstanding the abundance of some of the forms, occurred in only insignificant ratios, but were taken by fifty-six specimens, belonging to nineteen of the species,—more frequently by the sunfishes than by any other group. The kinds most commonly captured were larvæ of Gyrinidæ and Hydrophilidæ; whereas the adult surface beetles themselves (Gyrinus, Dineutes, etc.) — whose zigzag-darting swarms no one can have failed to notice — were not once encountered in my studies.

The almost equally well-known slender water-skippers (Hygrotrechus) seem also completely protected by their habits and activity from capture by fishes, only a single specimen occurring in the food of all my specimens. Indeed, the true water bugs (Hemiptera) were generally rare, with the exception of the small soft-bodied genus, Corisa, which was taken by one hundred and ten specimens, belonging to twenty-seven species, — most abundantly by the sunfishes and top minnows.

From the order Neuroptera fishes draw a larger part of their food than from any other single group. In fact, nearly a fifth of the entire amount of food consumed by all the adult fishes examined by me consisted of aquatic larvæ of this order, the greater part of them larvæ of day flies (Ephemeridæ), principally of the genus Hexagenia.* These neuropterous larvæ were eaten especially by the miller's thumb, the sheepshead, the white and striped bass, the common perch, thirteen species of the darters, both the black bass, seven of the sunfishes, the rock bass and the croppies, the pirate perch, the brook silversides, the sticklebacks, the mud minnow, the top min-

* The winged adults of this and related genera are often called "river flies" in Illinois.

nows, the gizzard shad, the toothed herring, twelve species each of the true minnow family and of the suckers and buffalo, five catfishes, the dog-fish, and the shovel fish,—seventy species out of the eighty-seven which I have studied.

Among the above, I found them the most important food of the white bass, the toothed herring, the shovel fish (fifty-one per cent.), and the croppies; while they made a fourth or more of the alimentary contents of the sheepshead (forty-six per cent.), the darters, the pirate perch, the common sunfishes (Lepomis and Chænobryttus), the rock bass, the little pickerel, and the common sucker (thirty-six per cent).

Ephemerid larvæ were eaten by two hundred and thirteen specimens of forty-eight species — not counting young. The larvæ of Hexagenia, one of the commonest of the "river flies," was by far the most important insect of this group, this alone amounting to about half of all the Neuroptera eaten. They made nearly one half of the food of the shovel fish, more than one tenth that of the sunfishes, and the principal food resource of half-grown sheepshead; but were rarely taken by the sucker family, and made only five per cent. of the food of the catfish group.

The various larvæ of the dragon flies, on the other hand, were much less frequently encountered. They seemed to be most abundant in the food of the grass pickerel, (twenty-five per cent.), and next to that, in the croppie, the pirate perch, and the common perch (ten to thirteen per cent.).

Case-worms (Phryganeidæ) were somewhat rarely found, rising to fifteen per cent. in the rock bass and twelve per cent. in the minnows of the Hybopsis group, but otherwise averaging from one to six per cent. in less than half of the species.

THE CRUSTACEAN ELEMENT.

Of the four principal classes of the animal food of fishes; viz., fishes, mollusks, insects, and Crustacea, the latter stand third in importance according to my observations, mollusks alone being inferior to them. That insect larvæ should be more abundant in the food of fresh-water fishes than are crustaceans, is a somewhat unexpected fact, but while the former made about

twenty-five per cent. of the food of our entire collection, the crustaceans amounted to only fourteen per cent. These divide conveniently into crayfishes, the medium-sized, sessile-eyed crustaceans (Isopoda and Amphipoda), and Entomostraca. The so-called fresh-water shrimps (Palæmon and Palæmonetes) appeared so rarely in the food that they need scarcely be taken into the account.

Crayfishes made about a sixth of the food of the burbot; about a tenth that of the common perch, a fourth that of half a dozen gars, not far from a third that of the black bass,* the dog-fish, and our four rock bass. Young crayfishes appeared quite frequently in some of the larger minnows (Semotilus and Hybopsis), and also in catfishes, especially the pond and river bull-heads, averaging nearly fifteen per cent. of the entire food of the two most abundant species.

The small, sessile-eyed crustaceans eaten by fishes were nearly all of four species; viz., *Allorchestes dentata*,— excessively abundant in the northern part of the State,— a species of Gammarus not uncommon in running streams, and two representatives of the isopod genera Asellus and Mancasellus. To fishes at large, this group is of little importance; but the perch of northern Illinois finds about one third of its food among them, and the common sunfishes (Lepomis) eat a considerable ratio (eleven per cent.). The miller's thumb of southern Illinois seems also to search for them among the stones.

The little Allorchestes mentioned above I found in a single white bass, in eleven of the common perch, in one of the largest darters, in five young black bass, in seventeen sunfishes of various species, in the rock bass, the pirate perch, a single grass pickerel and six top minnows, in only two of the true minnow family, in two only of the sucker tribe, in seventeen catfishes,— mostly young or of the smallest species,— in a single dog-fish, and in a single spoon-bill.[1] The common

* Our specimens — especially of the small-mouthed black bass — were too few in number to make this average reliable.

[1] Polyodon.

Asellus, or water wood louse, was less generally eaten; by only two of the miller's thumb, a single sheepshead, a white bass, four perch, two young black bass, eight sunfishes (Lepomis), two pirate perch, a grass pickerel, three small catfishes, and a dog-fish.

The minute crustaceans commonly grouped as Entomostraca are a much more important element. Among full-grown fishes, I find them especially important in the shovel fish,— where they made one third the food of the specimens studied, — in the common lake herring,[1] in the brook silversides (forty per cent.), in the stickleback (thirty per cent.), in the darter family (eleven per cent.), and in the mud minnows (ten per cent.). The perch had taken scarcely a trace of them. Among the sunfishes at large they were present in only insignificant ratio; but two genera (Pomoxys and Centrarchus), distinguished by long and numerous rakers on the anterior gill, had derived about one tenth of their food from these minute crustaceans. In the early spring especially, when the backwaters of the streams are filled with Entomostraca, the stomachs of these fishes are often distended with the commonest forms of Cladocera.

Notemigonus and Notropis among the minnows, represented in my collections by one hundred and twenty-five and one hundred specimens respectively, had obtained about a sixth of their food from Entomostraca.

Ten per cent. of the food of the sucker family consisted of them, mostly taken by the deep-bodied species Carpiodes and Ictiobus, in which they made a fourth or a fifth of the entire food. This fact is explained, it will be remembered, by the relatively long, slender, and numerous gill-rakers of these fishes. Large river-buffalo were occasionally crammed with the smallest of these Entomostraca,— the minute Canthocamptus, only a twenty-fifth of an inch in length.

I have several times remarked the peculiar importance of Entomostraca to the shovel fish,— one of the largest of our fresh-water animals,— a fact accounted for by the remarkable branchial strainer of this species, probably the most efficient apparatus of its kind known to the ichthyologist. Here,

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[1]Coregonus artedi.

again, the smallest forms were the most abundant. Generally, however, the Cladocera were more common than the other orders, the bivalve Cypris (most frequent in the mud) being much less abundant in the food. I have shown elsewhere,* at length, that Entomostraca compose by far the greater part of the food of young fishes of all descriptions,— with the partial exception of the sucker family, the young of which feed largely on still more minute organic forms,— and present an abstract of these facts in this article under another head.†

Particulars concerning the use of this abundant and varied group as food for fishes, are so numerous as to make them difficult to summarize, and the interested reader is again referred to the detailed list accompanying this paper.

VERMES AS FOOD FOR FISHES.

Probably to those accustomed to the abundance of true worms (Vermes) in marine situations, no feature of the poverty of fresh-water life will be more striking than the small number of this subkingdom occurring in the course of miscellaneous aquatic collections in the interior. Similarly we notice that in the food of fishes the occurrence of Vermes is so rarely noticed that they might be left out of account entirely without appreciably affecting any of the important ratios.

The minnows (cyprinoids) had eaten more of them than any other family,— three per cent. of the food of twenty-two specimens of Semotilus being credited to them, and one per cent. of that of thirteen specimens of Pimephales, besides a trace in the food of Notropis. More precisely analyzed, we find that a single Nais, a Lumbriculus, two examples of Gordius (doubtless taken as insect parasites) and several minute rotifers (wheel-animalcules) are the forms upon which this estimate is based.

A trace of Vermes likewise appears in the food of suckers, — mostly a polyzoan species (Plumatella) and minute rotifers sucked up with the mud.

* Bull. Ill. St. Lab. Nat. Hist., Vol. I., No. 3, pp. 75, 76.

† See pp. 495 and 496.

Catfishes alone seem purposely to eat leeches, these occurring in nine specimens of three different species of this family, and also in one common sucker and in a single shovel fish. This leech last mentioned and a small quantity of Plumatella were the only Vermes eaten by the shovel fishes which I examined.

A planarian worm occurred in one small stone cat, while rotifers were recognized in a common minnow, eight young red-horse, six young chub suckers,[1] five of the common sucker,[2] a single Carpiodes (young), and seven young buffalo. Polyzoa were noted, in addition to the instances above mentioned, in four common sunfishes, the croppie, and seven buffalo.

SPONGES AND PROTOZOA.

One of the fresh water sponges (Spongilla) had been eaten in considerable quantities by two examples of the spotted cat taken in September, but this element was not encountered elsewhere in my studies.

That the minutest and simplest of all the animal forms, far too small for the eye of a fish to see without a microscope, should have been recognized in the food of seventeen species of fishes is, of course, to be explained only as an incident of the feeding habit. It is possible, however, that these Protozoa, where especially abundant, may be recognized in the mass by the delicate sensory structures of the fish; and they seem in most cases to have been taken with mud and slime rich in organic substances, As most of them are extremely perishable, and can scarcely leave a trace a few seconds after immersion in the gastric juices of the fish, it is probable that they contribute much more generally than our observations indicate to the food of some fishes, especially to those which feed upon the bottom.

Young suckers under six inches in length clearly take them purposely, substituting them in great part for the Entomostraca taken by other fishes of their size and age.

I detected Protozoa in the food of several genera of Cyprinidæ, in the young of buffalo, the river carp, the chub sucker, the red horse, the stone roller,[3] in the common sucker,

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[1]Erimyzon sucetta. [2]Catostomus teres. [3]Hypentelium.

in a single gizzard shad, in a stone cat, and in a top minnow. The commonest forms, as would be supposed, were those protected by permanent shells; viz., Difflugia, Centropyxis, Arcella, and the like; but occasionally specimens of Actinosphærium, Euglena, and Dinobryon were present and recognized.

SCAVENGERS.

The only scavenger fishes of our collection were three species of the common catfishes; the spotted cat, the yellow cat, and the marbled cat,—all of which had eaten dead animal matter, including pieces of fish, ham, mice, kittens, and the like. A single large-mouthed black bass had likewise eaten food of this description.

VEGETABLE FEEDERS.

Considering the wealth of vegetation accessible to aquatic animals, and the fact that few other strictly aquatic kinds have the vegetarian habit, it is indeed remarkable that the plant food of fishes is an unimportant part of their diet. Taking our nine hundred specimens together, the vegetation eaten by them certainly would have amounted to less than ten per cent. of their entire food, and excluding vegetable objects apparently taken by chance, it probably would not reach five per cent.

The greatest vegetarians are among the minnow family, largely in the genera Hybopsis, Notemigonus, and Semotilus, thirteen specimens of the first and twenty-five of the second having taken about half their food from vegetable objects. One hundred and twelve Notropis, twenty-two Semotilus, eighteen Hybognathus, and nine Campostoma, had found in the vegetable kingdom a fourth or fifth of their food. Counting each genus as a unit, I find that the family as a whole obtained from plants about twenty-three per cent. of its food. The little Phenacobius, already reported as strictly insectivorous, was the only one studied in which vegetation can scarcely be said to occur.

The mud minnows (Umbridæ) are also largely vegetarian (forty-one per cent.); and likewise the cyprinodonts, the vegeta-

ble average in the food of thirty-three specimens being seventeen per cent. Plant structures made about one fourth the food of seven sticklebacks.

Certain of the sunfishes evidently take plant food purposely, on occasion, this making, for example, nearly a tenth of the food of forty-seven specimens of Lepomis. Among the larger fishes, the principal vegetarian is the gizzard shad, in which this element was reckoned at about a third,— taken, however, not separately, but with quantities of mud. A considerable part of it was distillery slops obtained near towns.

The buffalo fishes are likewise largely vegetarian, more than a fourth of their food coming from plants,—about a third of this in our specimens, refuse from distilleries. Vegetation made a tenth of the food of the larger genera of catfishes (Amiurus and Ictalurus),—some of it distillery refuse,—and nearly as large a ratio of that of the great Polyodon.

Not infrequently, terrestrial vegetable rubbish — seeds of grasses, leaves of plants, and similar matter — was taken in quantity to make it certain that its appropriation was not accidental.

Besides a great variety of Algæ, both filamentous and unicellular, including considerable quantities of diatoms, the principal plant forms found in the food of fishes were the duckweeds Lemna and Wolffia. The deep-bodied suckers, especially, occasionally take quantities of these little plants during the autumnal months.

MUD.

The principal mud-eating fishes are the gizzard shad, the common shiner, and the genera of minnows belonging to the groups with elongate intestines and cultrate pharyngeal teeth; viz., Pimephales, Hybognathus, Chrosomus, and Campostoma. Much mud was taken also by the cylindrical members of the sucker family, but apparently as an incident to their search for mollusks.

SUMMARY OF THE FOOD OF THE YOUNG.*

By an examination of three hundred and seven specimens, representing twenty-seven species, twenty-six genera, and twelve families of Illinois fishes, I learn that the food of many species differs greatly according to age, and that, in fact, the life of most of our fishes divides into at least two periods, and that of many into three, with respect to the kinds of food chiefly taken.

In the first of these periods a remarkable similarity of food was noticed among species whose later feeding habits are widely different. The full grown black bass, for example, feeds principally on fishes and crayfishes, the sheepshead on mollusks, and the gizzard shad on mud and Algæ, while the catfishes are nearly omnivorous; yet all these agree so closely in food when very small, that one could not possibly tell from the contents of the stomachs which group he was dealing with.

I will now summarize the facts concerning the earliest food of the principal species, taken *seriatim*.

The food of six common perch (*Perca lutea*) from an inch to an inch and a quarter long, consisted wholly of Entomostraca (ninety-two per cent.) and minute larvæ of Chironomus. No very small white bass (Labracidæ) were found, the youngest being an inch and a quarter long. Half the food of this consisted of Entomostraca, and the other half of minute gizzard shad. Forty-three sunfishes (Centrarchidæ) from five eighths of an inch to two inches long, had made ninety-six per cent. of their food of Entomostraca and the small larvæ of gnats (Chironomus) already mentioned, seventy per cent. of the first and twenty-six of the second. This group comprised five specimens of black bass under three quarters of an inch in length, two rock bass of similar size, two of the large-mouthed sunfish (Chænobryttus) from seven eighths of an inch to an inch long, nineteen of the commoner sunfishes (Lepomis) ranging in length from an inch to two inches, five of the genus Centrarchus, one inch and under, four croppies

* For detailed treatment of this topic see Bull. Ill. St. Lab. Nat. Hist., Vol. I., No. 3, p. 66, and No. 6, p. 95.

(Pomoxys) from three quarters of an inch to an inch and a half, and six indeterminable specimens, probably Lepomis, from seven sixteenths to five eighths of an inch long. A single sheepshead an inch and an eighth in length had eaten Chironomus larvæ (seventy-five per cent.) and larvæ of the "river fly" (Hexagenia). A single grass pickerel about an inch and a quarter long had taken about sixty per cent. of its food from Entomostraca and young Amphipoda, the remainder consisting of little fishes.

The first food of the common white-fish was determined experimentally, the breeding habits of this species making direct observation impossible. Three hundred and forty very young fry fed with fragments of the brook shrimp, Gammarus, in a hatching house, were examined in January, 1881, and thirty-five of them, which had apparently taken food, were dissected. Minute fragments of Gammarus were found in but eighteen of these, while five contained minute insect larvæ, four, Entomostraca, and eight, small particles of vegetation,—objects accidentally conveyed to them in the water of the hatching house. In two hundred and forty-two others, confined in spring water; only eight were found to have eaten anything, and these had taken only Algæ and vegetable fragments. In February of the same year, fourteen specimens, confined in a small aquarium and supplied with living objects, plant and animal, from stagnant pools, were proven to feed freely upon the smallest Entomostraca presented to them,—chiefly Cyclops and Canthocamptus, ten of the fourteen eating Cyclops, three Canthocamptus, and one a specimen of each.

A little later, a more extensive experiment was conducted by means of a large aquarium, in which there were placed several hundred fry, kept constantly supplied with all the living objects which a fine gauze net would separate from the waters of Lake Michigan. Of one hundred and six of these, dissected within the following fortnight, sixty-three had taken food consisting almost wholly of the smallest Entomostraca occurring in the Lake (a minute Cyclops and a slender Diaptomus). The other objects encountered were rotifers, and diatoms and other unicellular Algæ, appearing, however, in such trivial quantity as to contribute nothing of importance to the support of the fry.

A dozen specimens of small gizzard shad, ranging in length from four fifths of an inch to nearly two inches, had eaten about ninety per cent. of Entomostraca, two per cent. of Chironomus larvæ, and, for the remainder, Algæ.

The true minnows (Cyprinidæ) seem to agree with the suckers in the more minute character of their early food. Six examples — three eights to three fourths of an inch long — too small to determine, but apparently belonging to the genera Minnilus, had eaten Entomostraca, Chironomus larvæ, many Protozoa, and unicellular Algæ, a few filamentous Algæ and minute fungi and fungus spores, a water mite, and a few accidental insects. In several specimens of the common chub minnow (Semotilus), from five eighths of an inch to an inch in length, seven per cent. of the food was Entomostraca, and the remainder consisted of filamentous Algæ. It should be noted, however, that twenty per cent. of that of the smallest specimen, which was five eighths of an inch long, was Cyclops, and it may be that Semotilus lives wholly on Entomostraca at first, merely changing its habit earlier than most of its allies. Two other minnows of the genus Notropis, an inch and a half in length, had eaten nothing but Entomostraca. The Cyprinidæ, like the sucker family, are toothless when young.

Thirty young suckers were studied, representing five genera of their family. The very smallest were found feeding on Entomostraca only, and it is possible that these usually form the first food of the family; but later they resort to elements still more minute; viz., rotifers, Protozoa, and unicellular Algæ, quantities of which were found in the intestines of young suckers six inches or more in length. Young stone rollers (Hypentelium) not more than an inch and a half long, had taken chiefly larvæ of Chironomus (ninety per cent.), the remaining tenth being principally Entomostraca. A single small black sucker (Minytrema) had eaten little but Cyclops. Four chub suckers (Erimyzon), two three quarters of an inch, and two an inch and a quarter long, had eaten only Entomostraca and a trace of water mites. In two larger specimens, however, still minuter forms were the leading feature of the food, including rotifers, Protozoa, and unicellular Algæ. Another example, three inches long, had eaten a trace of

Chironomus larvæ, but for all the rest, one of the smallest of the Entomostraca (Canthocamptus). Ten young red horse (Moxostoma), varying in length from an inch to two and three fourths inches, had fed largely upon Protozoa,— especially the largest of the specimens,— but the smallest of them had taken a considerable amount of Entomostraca,—notably the bivalve cyprids occurring on the bottom. Two of the commonest buffalo fish (Ictiobus), seven eighths of an inch long, had eaten most freely of unicellular Algæ (sixty-three per cent.), the remainder of the food consisting of rotifers and Entomostraca. Four of the river carp (Carpiodes), seven eighths of an inch to two inches long, had fed like the preceding, except that the Entomostraca amounted to nearly half the food, while the rotifers were comparatively few.

Young catfishes, only three eighths of an inch in length, belonging to the genus Amiurus, but quite too small to be specifically determinable, were filled with various Entomostraca and Chironomus larvæ. Other examples of this genus, making thirteen in all, none longer than an inch and five eighths, had fed almost wholly on Entomostraca and larvæ of Chironomus, the latter, however, composing seventy-four per cent. of the food of all, and the former eighteen per cent. Six small stone cats (Noturus), varying in length from seven eighths of an inch to one and a half inches, had taken more Chironomus larvæ and scarcely any Entomostraca.

A single dog-fish (Amia), one and three fourths inches long, had eaten seventy per cent. of Entomostraca, a few larvæ of Chironomus, some small crustaceans, and aquatic insects. Others of the species, under an inch in length, had the intestine packed with Entomostraca. Of the common river gars one, an inch and a quarter long, had filled itself with minute Entomostraca, while two other specimens had eaten only the smallest fry of fishes.

To recapitulate, I find that, taking together the young of all the genera studied, considering each genus as a unit, and combining the minute dipterous larvæ with the Entomostraca as having essentially the same relation, about seventy-five per cent. of the food taken by young fishes of all descriptions is made up of these elements.

From the above it is clear that young fishes in general depend at first on Entomostraca and certain small insect larvæ (chiefly those of two genera of gnats), beginning with the smallest of these forms, or with those especially exposed to their attack. One-celled plants and animals are also eaten freely by the young of two of the largest families.

Correlated with these facts, I find that two at least of the genera, which are toothless when adult, have minute raptatorial teeth in this early stage; viz., Coregonus and Dorosoma. Otherwise young fishes have no apparatus specially adapted to the capture of their minute prey, but this is brought within their reach merely by their own small size and the corresponding minuteness of their structures of food prehension. Later, as the larger species grow, this apparatus becomes too coarse to retain objects so minute, but other food resources are made available, usually through some adaptive modification of the fishes themselves.

In other words, one-celled organisms and Entomostraca are the natural, and practically the only, food of an undifferentiated small fish; and to be at liberty to grow, the fish must either change its food (as is usually done) or must develop a special apparatus (commonly a set of fine long gill-rakers) for the separation of Entomostraca from the waters in which they swim.

Of the fishes which emerge from this earliest stage, through increase in size with failure to develop alimentary structures especially fitted to the appropriation of minute animal forms, some become mud-eaters, like Campostoma and the gizzard shad; a few apparently become vegetarians at once; but most pass into or through an insectivorous stage. After this a few become nearly omnivorous, like the bull-heads; others learn to depend chiefly on molluscan food,—the sheepshead and the red horse species,—but many become essentially carnivorous. In fact, unless the gars are an exception, as they now seem to be, (attacking young fishes almost as soon as they can swallow,) all our specially carnivorous fishes make a progress of three steps, marked, respectively by the predominance of Entomostraca, of insects, and of fishes, in their food; and the same is true of those strictly fitted for a molluscan diet.

While small fishes of all sorts are evidently competitors for food, this competition is relieved to some extent by differences of breeding season, the species dropping in successively to the banquet, some commencing in very early spring, or even, like the white-fish, depositing their eggs in fall, that their young may be the first at the board, while others delay until June or July. The most active breeding period coincides, however, with that of the greatest evolution of Entomostraca in the backwaters of our streams; that is, the early spring.

That large adult fishes, with fine and numerous rakers on the gills — like the shovel-fish and the river carp — may compete directly with the young of all other species, and tend to keep their numbers down by diminishing their food supply — especially in times of scarcity — is very probable, but is not certainly true; for these larger fishes have other food resources also, and may resort to Entomostraca only when these are superabundant, thus appropriating the mere excess above what are required for the young of other groups.

ON THE DEFINITENESS AND PERMANENCY OF THE FOOD HABITS OF FISHES.

It is always posssible that the seemingly specific differences of food exhibited by data derived from miscellaneous collections not strictly comparable as to dates and localities, are really due to differences of circumstance affecting the representatives of the species, and not to differences in the food habits or the regimen of the species in general. Date, locality, and other circumstantial conditions, may have more to do with the distinctions of food detected than structure and specific habit. It is true that the probability of such errors of inference is reduced to a minimum where alimentary peculiarities can be clearly correlated with peculiarities of structure, as has usually been done in my discussions; but to test still further the distinctness of species and genera with respect to food habits and preferences, I have assorted my observations according to dates and localities of the collections on which they were made and have compared species with species as occurring under the

same general conditions and at the same time. If perch and catfishes caught in the same haul of the seine show more marked differences in food between the two groups than those exhibited by the individuals of each group among themselves, the probability is considerable that the differences are specific instead of accidental; and such probability becomes greater the greater the number of species found to present corresponding differences under corresponding circumstances. Although it was rarely the case that examples enough of two or more species comparable as to size and range had been taken at the same time and place to afford a tolerable average of the food under local conditions, yet a sufficient number of such cases was found to give a considerable amount of evidence on this point.

Thus three specimens of the marbled cat, *Amiurus marmoratus*, taken at Peoria, Nov. 1, 1878, had derived nine tenths of their food from Hexagenia larvæ, the remainder consisting of leeches and a few spiders; while eight specimens of the large-mouthed black bass, *Micropterus salmoides*, taken at the same time and place, had eaten nothing but the young gizzard shad (Dorosoma).

Comparing the food of four examples of the channel cat *(Ictalurus punctatus)* with seven croppies (Pomoxys), both taken at Peoria, Apr. 10, 1878, I found that aquatic insects made ninety-eight per cent. of the food of the latter, seventy per cent. being Hexagenia larvæ, while only sixty-two per cent. of the food of the catfishes consisted of insects (ephemerid larvæ twenty-eight per cent.), the remainder consisting of vegetation and scraps of dead fishes.

A contrast equally decided is shown by three specimens of the gizzard shad (Dorosoma) and four of the rock bass *(Ambloplites rupestris)*, all obtained at Ottawa, July 8, 1879. The former had swallowed large quantities of fine mud containing about twenty per cent. of minutely divided vegetable *débris*, while the latter had fed wholly upon insects, fishes, and crayfishes,— the first chiefly aquatic larvæ.

Even in the shallow muddy pools left behind in the retreating overflow of the Mississippi in southern Illinois, fishes of the same size but differing widely in alimentary structures exhibit corresponding differences in the selections made from the

meager food resources of their localities. Two of the common blunt-jawed minnows *(Hybognathus nuchalis)* had fed here almost wholly upon mud mixed with Algæ and miscellaneous vegetation; while three of the little pirate perch (Aphredoderus) had eaten little but Chironomus larvæ, half the food of one of the specimens being wholly small fishes, and insignificant quantities of Entomostraca occurring in the stomachs of the others.

A small collection, made from the Little Fox River, in White county, in southern Illinois, Oct. 5, 1882, of four specimens each of Labidesthes and *Zygonectes notatus* enables us to bring into comparison the food of two extremely different species taken together from the same pools in a running stream. The Labidesthes, although predaceous in habit and feeding most commonly upon Entomostraca, was here giving its attention wholly to terrestrial insects,— more than two thirds of them winged Chironomus; while the Zygonectes had eaten in addition to thirty-seven per cent. of terrestrial insects (scarcely any of them Chironomus imagos), about thirty per cent. of aquatic vegetation, nine per cent. of Entomostraca, eleven per cent. of aquatic insects, and fourteen per cent. of mollusks. These differences in food have no apparent relation to the essential structural differences of the species, but must be considered an illustration of the various effect of like conditions when applied to different species.

On the other hand, three bull-heads *(Amiurus nebulosus)* and six common perch (Perca) taken from Fox River, at McHenry, May 9, 1880, did not differ remarkably in food, both groups having eaten crayfishes, mollusks, aquatic insects, and vegetation. One of the catfishes had taken another fish, and one had eaten leeches. It is to be noted, however, that these species are both bottom feeders, and that both lots of these specimens had taken about the average food of their kind.*

The above are examples of the food relations of fishes widely separated from each other in the classification and decidedly different in alimentary structures and in feeding habits. Illustrations of the differences in food apparent in

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* See Bull. Ill. St. Lab. Nat. Hist., Vol. I., No. 3, p. 35.

species allied in classification but differing with respect to the structures concerned in the appropriation of food are given by the following examples.

Two species of minnows, *Chrosomus erythrogaster* and *Semotilus atromaculatus* — the first represented by fourteen specimens, and the second by six, all collected from a small tributary of the Fox, near Plano, Sept. 8, 1882 — were brought into comparison with reference to their food, with the result that the characteristic differences of the species, as shown in the general discussion of the group published in our Bulletin 6, Vol. I., were clearly manifested by this small number. In the former lot seventy-five per cent. of the food was mud, the remainder being indiscriminate vegetable *débris*; while in the latter the entire mass consisted of insects (chiefly terrestrial) except a single insect parasite (Gordius).

From one of the permanent ponds or so-called lakes of southern Illinois, covered in September with a film of Wolffia and other vegetation, three specimens of *Gambusia patruelis* and five of *Umbra limi* were examined. The former had eaten little but Wolffia, which amounted to more than ninety per cent. of the food, the remainder consisting of Entomostraca, mollusks, and aquatic insect larvæ, while the Wolffia made less than sixty per cent. of the food of the Umbra,— about one fourth consisting of Entomostraca, and the remainder of unrecognized insects.

Two minnows of similar range (*Phenacobius mirabilis* and *Notropis whipplei*) agree essentially in gill structure and pharyngeal teeth, and differ but little in the relative length of intestine; and they have consequently been placed by me in the same alimentary group.* They are unlike, however, in the form of the mouth and in their haunts and feeding habits. This difference is reflected in the food of a small collection made in the Galena River, in April, 1880, three specimens of Phenacobius having eaten only aquatic larvæ and pupæ (nearly all chironomid), while the food of the Notropis, represented by six specimens, was of a varied character, containing few aquatic larvæ (only one per cent. of Chironomus), but consisting chiefly of miscellaneous collections of terrestrial insects,

* Bull. Ill. St. Lab. Nat. Hist., Vol. I., No. 6, p. 76.

seeds and anthers of terrestrial plants, and other accidental rubbish.

From a collection made at Henry, Illinois, Nov. 1, 1887, four specimens of croppie (*Pomoxys nigromaculatus*) are comparable with five sunfishes (*Lepomis pallidus*), and three large-mouthed black bass (*Micropterus salmoides*) may be compared with three striped bass (*Roccus chrysops*). Eighty-four per cent. of the food of the Pomoxys consisted of Hexagenia larvæ, an additional six per cent. being other aquatic larvæ, and the remaining ten per cent. consisting of fishes; while the Lepomis had eaten but twelve per cent. of Hexagenia larvæ, eight per cent. of other aquatic insects, and no fishes at all, — the remaining elements being terrestrial insects (about one fourth), worms (Nais and Lumbriculus, fifteen per cent.), and mollusks (thirty-seven per cent.).

The black bass had eaten chiefly fishes and a mouse, together with a few aquatic insects; while the food of the striped bass was nearly all ephemerid larvæ with only a trace of fishes.

A collection of small fishes, made from Mackinaw Creek, in Woodford county, August 20, 1879, affords an interesting opportunity to compare the food of a number of the smaller species (cyprinoids, darters, etc.). About half that of four specimens of *Notropis megalops* collected there, consisted of insects, the remainder being terrestrial and aquatic vegetation; and substantially the same statement may be made with respect to six specimens of *Notropis whipplei*, — these two species belonging respectively to the third and fourth groups of my paper on the "Food of the Smaller Fresh Water Fishes."*

Two specimens of *Hybopsis biguttatus*, on the other hand, had eaten only aquatic vegetation; and two examples of Phenacobius — a species extremely darter-like in its haunts and habits — had taken only Chironomus larvæ.

The darters were represented by four examples of Boleosoma and six of Hadropterus, the former and smaller species having eaten mostly Chironomus larvæ and Entomostraca, — eighty-nine per cent. and eleven per cent. respectively, — while the larger had taken only aquatic larvæ, — nearly all ephemerids.

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* Bull. Ill. St. Lab. Nat. Hist., Vol. I., No. 6, p. 76.

Finally, eight of the slender, active, and wholly predaceous little brook silversides (*Labidesthes sicculus*) had eaten a single fish, fourteen per cent. of Entomostraca, and about eighty per cent. of insects — somewhat more than half of aquatic origin. In brief, the structures of Labidesthes, the habits of Phenacobius and the darters, and the differences in size of the species of Boleosoma and Hadropterus were all reflected in the food of this little group.

The obverse fact of the unifying effect of similarity of alimentary structures is apparently shown by a small collection of minnows, all belonging to the first two groups of the paper cited above*, made from an extremely muddy little creek in Jersey county, which contained no visible vegetation and few, if any, Entomostraca. Twelve of these fishes, representing the genera Campostoma, Pimephales, Hyborhynchus, Hybognathus, and Notemigonus, agreed in food almost precisely, all having swallowed the fine mud of the creek bottom, with a slightly varying admixture of unicellular Algæ and vegetable *débris.*

As an example of a contrast between two species agreeing in alimentary structures, but differing in size and somewhat, also, in habitual range, we may take three examples of *Notropis heterodon* and three of *Notropis megalops,* captured at McHenry, May 8, 1880. More than half the food of the latter group consisted of vegetation, and of the former only ten per cent. The remaining ninety per cent. of the food of *heterodon* was Entomostraca ; but these were not represented at all in the *megalops*, the remaining food of these specimens consisting of insects and amphipod Crustacea.

Sensible and even conspicuous differences in food often appear between groups which are neither widely separate in classification nor yet distinguished by marked differences in alimentary structures, as between species of the same genus. Sometimes these are apparently due to differences in habit with respect to the search for food; but sometimes seem dependent upon distinction of habit or preferences even more obscure.

Six specimens of the channel cat (*Ictalurus punctatus*), taken at Peoria, October 6, 1887, had eaten insects, mollusks, and vegetation at the rate of forty-one, nineteen, and forty per cent. respectively, the vegetation being nearly all Claduph-

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* See the preceding page.

ora and Potamogeton; while the same number of bull-heads (*Amiurus nebulosus*) had derived thirty-seven per cent. of their food from insects, and sixty-three per cent. from mollusks. The difference here was substantially a larger ratio of mollusks for Amiurus, replacing the vegetable food of the Ictalurus group. By a comparison of these differences with those detected between the species at large, as explained on pages 456–461, it will be seen that the former do not represent the specific differences in food, but simply give evidence that two species may be differently affected by the same conditions.

Other specific differences in the same genus are shown by the collections made Oct. 27, 1875, from Peoria Lake. Eight examples of the wall-eyed pike (*Stizostedion vitreum*) had eaten only soft-finned fishes, — excepting one small sunfish, — while four of ten specimens of the related species *S. canadense*, had eaten spiny-finned fishes, and in only three were the fishes recognizable as belonging to the soft-finned species. Three specimens of Micropterus taken with the above had eaten crayfishes and fishes (including a catfish).

Among my specimens of the sucker family (Catostomatidæ), a lot obtained at Quincy, Aug. 25, 1887, are comparable for the present purpose. Four examples each of *Ictiobus urus* and *I. cyprinella* presented a decided contrast with respect to the elements of their food, that of *I. urus* consisting almost wholly of Chironomus larvæ, with large quantities of dirt, while three of the specimens of *I. cyprinella* had eaten scarcely anything but Algæ, ninety per cent. of the food of the fourth being Chironomus larvæ, and the remainder, larvæ of Neuroptera,— Hexagenia and Corydalis.

On the other hand, two small collections of the same species made at Peoria, Oct. 9, 1878 — four of *I. urus* and five of *I. cyprinella* — exhibit similar food, composed chiefly of Entomostraca, Chironomus larvæ, distillery waste (meal, etc.), and aquatic vegetation. The *urus* group alone had eaten Entomostraca, these being replaced in the other by a larger quantity of meal.

The facts above recited are evidence that fishes are not mere animated eating-machines, taking indiscriminately and indifferently whatever their structures fit them to capture, to

strain from the waters, or to separate from the mud, but that psychological preferences as well as physical capabilities have something to do with their choice of food.

THE STRUCTURES OF ALIMENTATION.

A brief review of the principal facts respecting the structures of alimentation in fishes will be necessary to exhibit clearly the relation of habit and organization in this particular.

These structures may be conveniently divided into those of *search*, of *prehension*, of *mastication*, and of *digestion*. Means of defence and escape may also properly be mentioned, as belonging to the obverse side of the food relation.

Structural peculiarities relating to the methods and situation of the search for food are illustrated by the barbels of the catfishes and the sturgeons, the shovel of Polyodon, the square head of the stone roller, the flat heads of the top minnows, and the pointed snouts of the darters,— which fit them for prying about between and under stones in running water. Similarly related, are the bare breasts of many darters and the large pectoral fins of the stone roller and Phenacobius.

The structures of food prehension are the lips, the jaws, the teeth, and the gill-rakers, with which should be considered, perhaps, the gill slit or branchial opening. The sucking lips of the Catostomatidæ, organs of touch as well as of prehension, are of course related to the mud-searching habit of these fishes, the protractile jaws aiding in this use. The stout wide jaws of the catfishes, with their wide bands of minute, pointed teeth, are probably to be understood as an apparatus for seizing, holding, and pulling about relatively large objects, whether hard or soft, and are perhaps most useful in feeding upon mollusks. The very large but weak jaw of the shovel fish is explained by the minute character of its food, which offers no resistance, but necessitates the passage of large quantities of water through the mouth; while the long and slender jaws of the long-nosed gar (Lepidosteus) armed with several rows of acute raptatorial teeth, are the best apparatus in our waters for the destruction of a relatively small but active living prey.

The teeth of our fresh-water fishes are always pointed and acute, there being no examples of pavement teeth or cutting incisors among them, such as are found in several marine forms, nor are there any instances of either jaw being toothed and the other not. The evanescent teeth of the young of several species which become toothless when mature, are sometimes to be understood as rudiments, as in the shovel fish, and sometimes as related to the early food, as in the white-fish and the gizzard shad.

The gill-rakers of fishes vary widely in number, length, and usefulness, but are as important and significant as any other part of the feeding apparatus. As they oppose the only obstacle to the escape through the gill slit, of objects which enter the mouth with the water of respiration, they set the minimum of size for objects of the fishes' food, the only exception to this rule being afforded by the few fishes which swallow mud with little or no discrimination.

They are usually arranged in two rows on each gill arch, with frequently one also on the pharyngeal, behind the last gill slit. Occasionally only one row is developed on each gill (lake "herring"), and commonly the second row, if present, is less prominent than the first. The shovel fishes are, however, an exception to this latter statement, for in them both rows are equally and remarkably developed. As the anterior rakers guard the relatively large passage-way between the foremost gill and the opercle, while the other rows merely prevent the escape of objects between the several pairs of gills, the anterior row is almost invariably longer than the remaining series. The shovel fish and the gizzard shad are exceptions. The rakers of this row are commonly longest in the middle of the arch, shortening toward each end; but the particulars of this disposition depend on the length and shape of the arch and the concavity of the inner surface of the opercle. In the gizzard shad, however, the short but very numerous and fine gill-rakers project in a nearly horizontal direction.

The gill-rakers, when short and ineffective, are often armed with minute denticles, variously arranged, but are never branched or pinnate. In several of the sucker family, the rakers of the lower horizontal arm of the arch are represented

by a thick, broad pad, transversely ridged (the ridges representing the separate rakers) so that when approximated these structures form a continuous floor for the sides of the buccal cavity. The rakers may vary in number in different species from ten or twelve in a series, as in some sunfishes, to more than five hundred, as in the shovel fish; and in length from mere tubercles, to two or three times the length of the corresponding filaments of the gill. Rarely they are completely wanting, as in the pike. The anterior row is commonly so set upon the arch as to be obliquely divaricated by the separation of the branchial structures, being thus automatically adapted to the respiratory movements.

They are little developed in young fishes, the small branchial arches and the narrow slits between them serving to separate from the water the minute objects of the earliest food. Their development with the growth of the fish simply enables it to retain as elements of its dietary, objects which the coarseness of its branchial structures would otherwise compel it to forego.

Concerning their relations to food prehension, we may say in general that if numerous, long, and fine, they indicate the importance of Entomostraca to the fish. If less numerous, but moderately long and stout, in a fish of medium size, we may presume that insects form a considerable ratio of the food. If wanting, or rather short and strong, the presumption is (except for the smaller fishes) that the species is either piscivorous or feeds largely upon mollusks, the dental and pharyngeal apparatus easily showing which.

The pike-perch (Stizostedion) is somewhat remarkable in the fact that although strictly piscivorous when adult, it has long and strong gill-rakers, much longer in fact than in the less piscivorous related species, the common perch. In this case the rakers seem to have been retained, and even further developed, as a basis of attachment for several rather large recurved teeth borne on their inner surfaces, useful in preventing the escape of a living prey.

The masticatory apparatus of fishes (sometimes wanting) comprises always a pair of pharyngeal bones,—the lower pharyngeal jaws, a pair of modified branchial arches. These are

commonly opposed by superior pharyngeals, which most frequently consist of osseous and cuticular thickenings of the upper ends of the gill arches, — sometimes of only one or two, as in the catfish family, sometimes of all, as in the sunfishes. In the cyprinoids, the upper pharyngeal is a quadrate or triangular pad, rarely, if ever, toothed, borne upon an oblique, expanded process of the basioccipital. In the sucker family the sickle-shaped lower pharyngeals act against a more or less indurated palatal arch supported by the same cranial process, the firmness and width of this hardened band varying with the development of the lower arches of the apparatus. In most of the Acanthopteri and in the catfish family the lower pharyngeals have a fusiform outline, varying in width according to the food, the upper surface set with minute denticles, sharp-pointed in the insectivorous species, more or less blunt and conical in those which take a considerable percentage of molluscan food. The immense development of these structures in the sheepshead (Aplodinotus), as a crushing apparatus for Mollusca, is too well known to require description. In the Catostomatidæ the number of teeth may vary from thirty or less to two hundred or more, reduction in number going with increase in size (especially in the lower part of the arch,) both being related to an increased importance of molluscan food.

In the cyprinoids or minnow family, this is practically an insectivorous apparatus, except in some of the species with very long intestine and the limophagous habit, where it seems useful chiefly as a means of grinding up the mud ingested.

In the piscivorous species, and in those with highly developed gill-rakers, the lower pharyngeals are commonly slight and insignificant; but in the former group the upper pharyngeals may be preserved and enlarged as a basis for the insertion of hooked teeth, to aid in the retention of their struggling prey.

Concerning the digestive structures, I will only remark that the fishes with the longest intestine are mud-feeders, as a rule, and that in one of them, — the gizzard shad, a mud lover, *par excellence*, — the pharyngeal jaws (which in the mud-eating cyprinoids are evidently used to grind the food) are function-

ally replaced by a bulbous, muscular stomach, the pharyngeals themselves being reduced to thin and delicate plates, scarcely better than rudiments.

In this connection the adult size of the fish ought always to be mentioned, since this has, perhaps, at least as much to do with the food as any structural endowment, and frequently, in fact, has had a determining influence on the latter. Many fishes can enjoy the advantages of large size only on condition that they acquire some new capacity of food prehension, adapting them to new food relations. Simple and symmetrical growth of a small fish would render it incapable of straining out Entomostraca without fitting it for the appropriation of any other food, except, perhaps, the larger Crustacea and some aquatic insects; and beyond this insectivorous stage nothing is possible without new adaptations.

CORRELATIONS OF ALIMENTARY ORGANS.

Correlations of structure may be either mediate or immediate, in the latter case modification of one organ being directly dependent on modification of another, and in the former both parties to the correlation being modified by a common cause. The immediate class of correlations are relatively few and simple in the alimentary structures of fishes, while several of the mediate class are less obvious and more suggestive. That a fish with canine teeth has a strong jaw is a less interesting fact than the weakness of the jaw in one with long and numerous gill-rakers, or the incompatibility of canine teeth and heavy lower pharyngeals. The first is an immediate adaptive adjustment which a child might foresee, while the others are to be understood only when the peculiarities of the food are known to which both owe their character. The weak jaw of the shovel fish and the slight lower pharyngeals of the pike-perch illustrate the law of disuse (especially when we take into account the teeth of the young in the former and the large pharyngeals of the common perch), and the branchial apparatus of the shovel fish and the canine teeth of the pike-perch are examples of special adaptation to particular kinds of food.

Some mediate correlations are inverse, others coincident, the related structures varying oppositely or in the same direction. An interesting inverse correlation is exhibited by the gill-rakers and the pharyngeals in the suckers; as the former lengthen and multiply, the latter become weaker and bear smaller and more numerous teeth. The cause of this correlation is seen in the food, the species with heavy pharyngeals, few and large pharyngeal teeth, and few and short gill-rakers being mollusk feeders, and the other group depending largely on insects and crustaceans and using mollusks sparely, and then only the small and thin-shelled sorts. A similar inverse relation is seen between the large mouths and the weak pharyngeals of many piscivorous fishes; between the weak pharyngeals and the muscular stomach of the gizzard shad; and between the long gill-rakers and the rudimentary pharyngeals of the shovel fish. Such correlations are often evidence of a specialization and corresponding limitation of the feeding habit, — the increased efficiency of one structure corresponding to the increased importance to the fish of the related kind of food, and the defective development of the correlated structure indicating an abandonment of the food for whose appropriation it was especially fitted. On the other hand, the absence of these inverse correlations marks an omnivorous habit, — as in the cat-fishes, whose jaws, teeth, gill-rakers, and pharyngeals are all moderately developed, while the food is correspondingly indiscriminate.

DETAILED RECAPITULATION OF DATA.*

ANIMAL FOOD.

Dead animal matter: 1 Micropterus salmoides, Nov.; 6 Ictalurus punctatus, Mar., Apr., June, Aug.; 2 Amiurus natalis, May; 1 A. marmoratus, Oct.

Tadpoles: 2 Esox vermiculatus, June, July.

FISHES.

Ctenoid fishes: 1 Uranidea richardsoni, Aug.; 1 Esox lucius, Sept.

Cycloid fishes: 1 Stizostedion canadense, Nov.; 1 Esox lucius, May, Nov.; 2 E. vermiculatus, July; 1 Ictalurus punctatus, Aug.

ACANTHOPTERI.

Undetermined: 11 Stizostedion canadense, June; 1 Micropterus salmoides, Nov.; 3 Pomoxys, Oct., Nov.; 1 Esox lucius, Sept.; 1 Amia calva, Oct.

Aplodinotus grunniens: 2 Stizostedion canadense, Oct.

Percidæ: 1 Perca lutea, May.

Perca lutea: 8 Lota maculosa, Nov.; 1 Micropterus salmoides, May; 1 Amiurus nebulosus, May.

Etheostomatinæ: 1 Lepomis pallidus, Nov.

Etheostoma: 1 Perca lutea, Oct.

Percina caprodes: 1 Micropterus dolomiei, June.

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* The figures in the following lists show the number of examples of the species of fish in which the given food element was detected.

Where a family or other general name above that of a species occurs in the body of the list, the data placed against it are to be understood as relating only to specimens of the group not further determined; the species names, for example, placed against the family names Percidæ, Cyprinidæ, and the like, indicate the species and specimens in whose food *undetermined* examples of those families were noted—the more precise determinations being given lower down.

Boleosoma maculatum: 1 Pomoxys, Mar.
Centrarchinæ: 1 Stizostedion canadense, Nov.; 1 S. vitreum, Oct.; 4 Esox lucius, Sept., Oct.; 1 E. vermiculatus, 5 in., Oct.; 1 Amiurus nebulosus, Aug.
Micropterus: 1 Esox lucius, Nov.; 1 Lepidosteus platystomus, June.
M. dolomiei: 1 Stizostedion canadense, Nov.; 1 Esox lucius, Nov.
Lepomis: 1 Leptops olivaris, Aug.
Ambloplites rupestris: 1 Esox lucius, Nov.
Pomoxys: 1 Esox lucius, Sept.

HAPLOMI.

Gambusia patruelis: 1 Esox vermiculatus, July.

ISOSPONDYLI.

Coregonus artedi: 1 Lota maculosa, Nov.
C. clupeiformis: 1 Lota maculosa, Nov.
Dorosoma cepedianum: 2 Roccus interruptus, yg.; 4 Stizostedion canadense, Oct., Nov.; 7 S. vitreum, Apr., Oct.; 8 Micropterus salmoides, Nov.; 16 Esox lucius, Sept., Oct.; 2 Clupea chrysochloris, Sept., Oct.; 1 Amiurus natalis, Oct.; 1 Lepidosteus platystomus, Sept.; 2 L. osseus, July.
Hyodon: 1 Esox lucius.

EVENTOGNATHI.

Cyprinidæ: 2 Stizostedion vitreum, Oct.; 4 Perca lutea, May, Oct.; 1 Micropterus dolomiei, yg.; 1 Lepomis cyanellus; 1 Pomoxys, Oct.; 1 Aphredoderus sayanus, July; 3 Esox lucius, Nov.; 2 E. vermiculatus, July, Oct.; 1 Semotilus atromaculatus, July; 1 Amiurus natalis, Aug; 1 Leptops olivaris, Aug.; 2 Amia calva, May; 1 Lepidosteus platystomus, June; 1, $1\frac{3}{4}$ in., June; 1 L. osseus, July; 1, 2 in., July.
Semotilus atromaculatus: 1 Stizostedion vitreum, Oct.
Notropis: 1 Pomoxys, Mar.
N. hudsonius: 1 Esox lucius, Nov.
Campostoma anomalum: 1 Micropterus salmoides, Nov.
Catostomatidæ: 1 Aplodinotus grunniens, Sept.; 1 Esox lucius, Sept.; 1 Amiurus natalis, Aug.

Ictiobus: 1 Lepomis cyanellus, July; 2 Esox lucius, Nov.; 1 Amia calva.

I. bubalus: 1 Esox lucius, Sept.

Carpiodes: 1 Esox lucius, Nov.

NEMATOGNATHI.

Siluridæ: 1 Stizostedion canadense, Nov.; 1 Micropterus salmoides, Oct.

Amiurus: 1 Stizostedion canadense, Oct.; 1 Leptops olivaris, Aug.

Noturus flavus: 1 Micropterus dolomiei; June.

MOLLUSCA.

GASTEROPODA.

Pleurocera: 1 Ictalurus punctatus, Sept.

Amnicola: 4 Lepomis gibbosus, May, July, Aug.; 1 L. notatus, Sept.; 1 L. pallidus, Oct.; 2 Placopharynx carinatus, Oct.; 1 Moxostoma, Nov.; 1 M. macrolepidotum, Sept.; 1 Minytrema melanops, Oct.; 1 Ictalurus punctatus, Oct.; 3 Amiurus nebulosus, May, Aug., Oct.

Somatogyrus: 3 Moxostoma macrolepidotum, Sept.

Valvata tricarinata: 1 Perca lutea, May; 2 Lepomis gibbosus, May; 2 Notemigonus chrysoleucus, May; 1 Placopharynx carinatus, Oct.; 2 Moxostoma macrolepidotum, Sept; 1 Ictiobus urus, Aug.; 1 Amiurus nebulosus, July.

V. sincera: 1 Gambusia patruelis, Sept.

Vivipara: 2 Lepomis pallidus, July, Nov.; 1 Moxostoma aureolum, June; 3 M. macrolepidotum, Sept., Oct.; 1 Ictiobus bubalus, Oct.; 7 Ictalurus punctatus, Apr., Sept., Oct.; 2 Amiurus natalis, Oct.; 1 A. marmoratus, Oct.; 1 Amia calva, Aug.

Melantho: 1 Moxostoma, Nov.; 3 M. macrolepidotum, Oct.; 7 Ictalurus punctatus, Sept., Oct.; 1 Amiurus natalis, Oct.; 1 A. nebulosus, Oct.

M. decisa: 2 Aplodinotus grunniens, Oct.

Lioplax subcarinata: 2 Ictalurus punctatus, Sept.

Succinea: Perca lutea, Aug.

Limnæa: 1 Notropis whipplei, Apr.; 1 Moxostoma macrolepidotum, May.

Physa: 1 Lepomis gibbosus, yg.; 2 L. pallidus, Nov.; 1 Umbra limi, Sept.; 3 Gambusia patruelis, Sept., Oct.; 1 Zygonectes dispar, July; 3 Z. notatus, Sept., Oct.; 1 Moxostoma macrolepidotum, May; 2 Amiurus natalis, 2½ in., July; 3 A. nebulosus. Aug., Sept.; 1 A. marmoratus, Aug.

P. heterostropha: 2 Perca lutea, May; 1 Amiurus nebulosus, Oct.

Planorbis: 1 Aplodinotus grunniens, June; 1 Lepomis gibbosus, July; 1 L. notatus, Sept.; 1 L. pallidus, Nov.; 1 Umbra limi, July; 1 Gambusia patruelis, Sept.; 1 Zygonectes dispar, July; 2 Fundulus diaphanus, June, Oct.; 2 Moxostoma macrolepidotum, May, Sept.; 2 Ictiobus bubalus, Oct.; 1 Ictalurus punctatus, Oct.; 1 Amia calva, Aug.

P. deflectus, yg.: 1 Notemigonus chrysoleucus, May.

Ancylus: 1 Percina caprodes, Aug.

LAMELLIBRANCHIATA.

Sphærium: 2 Aplodinotus grunniens, June, Oct.; 1 Perca lutea, Oct.; 1 Lepomis pallidus, Oct.; 1 Dorosoma cepedianum; 1 Placopharynx carinatus, Oct.; 4 Moxostoma, June; 1 M. aureolum, June; 3 M. macrolepidotum, June, Sept.; Minytrema melanops, Sept., Oct.; 2 Hypentelium nigricans, Aug.; 1 Catostomus teres, Oct.; 3 Ictiobus velifer, Aug., Oct.; 7 I. bubalus, Aug., Oct.; 4 I. urus, Aug., Nov.; 2 I. cyprinella, June, Oct.; 13 Amiurus nebulosus, May, Sept., Oct.; 1 A. marmoratus, Oct.; 2 Amia calva, Sept.

S. sulcatum: 1 Ictiobus bubalus, Oct.; 4 Amiurus nebulosus, Sept.; 1 A. marmoratus, Aug.

Pisidium: 1 Fundulus diaphanus, June; 1 Amiurus nebulosus, Sept.

Unionidæ: 1 Lepomis notatus, Sept.; 1 Labidesthes sicculus, Oct.; 1 Ictiobus urus, Apr.; 2 Ictalurus punctatus, Sept.; 2 Amiurus nebulosus, May, Oct.; 1 A. marmoratus, Oct.

Unio: 1 Aplodinotus grunniens, June; 1 Perca lutea, May; 2 Lepomis gibbosus, yg.; 1 Moxostoma macrolepidotum, May; 1 Catostomus teres, June.

Anodonta: 2 Aplodinotus grunniens, June; 1 Lepomis megalotis, June; 2 Ictalurus punctatus, Aug., Oct.

INSECTA.

Eggs: 4 Lepomis gibbosus, yg.; 1 L. pallidus, July; 1 Hyodon tergisus, Oct.; 1 Notropis hudsonius, June; 1 N. stramineus, Apr.; 1 Amiurus natalis, Nov.

Pupæ: 1 Perca lutea, Oct.; 1 Hadropterus phoxocephalus, Apr.; 1 Notropis megalops, June; 1 N. whipplei, Aug.

Larvæ: 1 Uranidea richardsoni, Aug.; 1 Micropterus salmoides, yg.; 1 Lepomis pallidus, yg.; 2 L. megalotis, June; 1 L. cyanellus, yg.; 1 Ambloplites rupestris, July; 1 yg.; 1 Umbra limi, Sept.; 1 Zygonectes notatus, Sept.; 1 Dorosoma cepedianum, 2½ in., July; 1 Semotilus atromaculatus, July; 1 Notropis megalops, June; 1 N. whipplei, June; 1 Moxostoma aureolum, June; 1 M. macrolepidotum, May; 1 Ictiobus urus, Aug.; 2 I. cyprinella, July; 2 Ictalurus punctatus, Apr., June; 2 Amiurus natalis, 2–2⅛ in., July.

Terrestrial: 1 Dorosoma cepedianum, July; 3 Hyodon tergisus, May, June, Aug.; 3 Notropis megalops, May, July, Aug.; 1 N. whipplei, June; 1 Ictiobus bubalus, Oct.; 1 I. cyprinella, Oct.

Terrestrial pupæ: 1 Notropis analostanus, Oct.

Aquatic: 1 Notropis whipplei, June; 2 Ictiobus bubalus, Oct.; 1 Ictalurus punctatus, Sept.; 1 Polyodon spathula, Aug.

Aquatic larvæ: 3 Uranidea richardsoni, Aug.; 1 Lepomis gibbosus, yg.; 1 L. notatus, Sept.; 1 L. pallidus, July; 3 Aphredoderus sayanus, Sept.; 1 Semotilus atromaculatus, May; 1 Hybopsis biguttatus, Aug.; 3 Notropis megalops, May, June; 3 N. whipplei, Apr., June; 1 N. lutrensis, July; 1 N. heterodon; 1 Hypentelium nigricans, Aug.; 1 Ictiobus velifer, Oct.; 1 I. urus, Aug.; 1 I. cyprinella, Oct.; 1 Ictalurus punctatus, Apr.; 1, 2½ in., Sept.; 2 Noturus gyrinus, June; 1 Polyodon spathula, June.

HYMENOPTERA.

Undetermined: 2 Lepomis pallidus, Nov.; 1 Pomoxys, May; 1 Labidesthes sicculus, Oct.; 4 Zygonectes notatus, July, Sept., Oct.; 1 Semotilus atromaculatus, June; 1 Notropis atherinoides, Apr.; 1 N. megalops, June; 1 N. whipplei, Apr.

Apis mellifica: 1 Hyodon tergisus, May; 1 Ictalurus punctatus, Oct.

Sphegidæ: 1 Hyodon tergisus, Oct.

Larrada montana: 1 Hyodon tergisus, Oct.

Formicidæ: 1 Lepomis pallidus, Nov.; 1 Centrarchus macropterus, July; 1 Coregonus artedi, 6 in., Aug.; 3 Semotilus atromaculatus, July, Aug.; 1 Notropis megalops, July; 3 N. whipplei, Aug.; 1 Ictalurus punctatus, Oct.; 1, 3½ in., Sept.

Myrmicidæ: 1 Gambusia patruelis, Sept.; 1 Zygonectes notatus, Sept.; 1 Coregonus artedi, Oct.; 1 Ictalurus punctatus, Oct.

Solenopsis: 1 Zygonectes notatus, July.

Chalcididæ: 2 Labidesthes sicculus, Oct.; 1 Fundulus diaphanus, Oct.

Eurytominæ: 1 Clupea chrysochloris, 2¼ in., Sept.

Ichneumonidæ: 1 Lepomis pallidus, July.

Amblyteles subrufus: 1 Hyodon tergisus, Oct.

LEPIDOPTERA.

Undetermined: 1 Coregonus artedi, Oct.; 2 Hyodon tergisus, Oct.; 1 Hybopsis biguttatus, Nov.; 3 Notropis megalops, July, Aug.; 1 N. whipplei, June.

Larvæ: 3 Lepomis pallidus, May, July, Nov.; 1 Ambloplites rupestris, yg.; 1 Semotilus atromaculatus, July; 1 Hybopsis biguttatus, June; 1 Notropis atherinoides, Apr.; 2 N. whipplei, Aug.; 1 Pimephales promelas, May; 1 Ictalurus punctatus, Oct.

Heterocera: 1 Notemigonus chrysoleucus, July.

DIPTERA.

Terrestrial: 2 Lepomis cyanellus, yg.; 6 Labidesthes sicculus, June, Aug., Oct.; 1 Coregonus artedi, 2 in., Aug.; 1 Clupea chrysochloris, 2¼ in., Sept.; 1 Hyodon tergisus, Oct.; 2 Notemigonus chrysoleucus, Sept.; 3 Semotilus atromaculatus, June, Sept.; 2 Notropis atherinoides, July; 2 N. whipplei, Aug.; 2 N. heterodon, May, July; 1 Moxostoma macrolepidotum, Sept.; 2 Ictalurus punctatus, Apr.; 1 Amiurus nebulosus, 2 in., Aug.; 1 Noturus flavus, Oct.; 1 Polyodon spathula, Aug.

Aquatic larvæ: 2 Uranidea richardsoni, Aug.; 2 Aplodinotus grunniens, June, Sept.; 1 Roccus chrysops, Nov.; 1 Etheostoma fusiforme, July; 3 E. cœruleum, June, July; 2 E. zonale, June; 1 Hadropterus phoxocephalus, Apr.; 1 Percina caprodes, Aug.; 1 Boleosoma maculatum, July; 1 Ammocrypta pellucida, June; 2 Lepomis gibbosus, yg.; 1 L. megalotis, June; 1 L. cyanellus, yg.; 2 Chænobryttus gulosus, yg., 1 Ambloplites rupestris, July; 3 Pomoxys, Apr.; 5 Aphredoderus sayanus, Sept.; 4 Eucalia inconstans, Oct.; 1 Umbra limi, July; 1 Gambusia patruelis, Sept.; 4 Zygonectes notatus, June, Sept., Oct.; 7 Fundulus diaphanus, June, Oct.; 1 Dorosoma cepedianum, $2\frac{1}{2}$ in., July; 1 yg.; 1 Hybopsis biguttatus, Sept.; 1 Notropis atherinoides, Aug.; 2 N. megalops, May; 4 N. whipplei, June; 1 N. stramineus, Apr.; 4 N. heterodon, May, July; 1 Pimephales promelas, May; 1 Placopharynx carinatus, Oct.; 1 Moxostoma, Nov.; 1 M. aureolum, June; 5 M. macrolepidotum, June, Sept., Nov.; 1, 2 in., July. 1 Minytrema melanops, Oct.; 1 Erimyzon sucetta, $3\frac{1}{4}$ in.; 2 Hypentelium nigricans, Aug.; 8 Ictiobus velifer, Apr., July, Oct.; 1 I. bubalus, Oct.; 7 I. urus, Apr., June, July, Aug., Oct., Nov.; 4 I. cyprinella, Apr., June, July, Oct.; 12 Ictalurus punctatus, Apr., May, June, Aug., Oct.; 1, $2\frac{1}{2}$ in., Sept.; 4 Amiurus, yg.; 1 A. natalis $2\frac{1}{2}$ in., July; 2 A. nebulosus, Oct.; 3 Noturus gyrinus, May, Oct.; 2 Polyodon spathula, May, June.

Nemocera: 2 Notropis atherinoides, Aug.; 4 N. whipplei, May; 1 N. heterodon, May.

Brachycera: 4 Labidesthes sicculus, Oct.; 1 Zygonectes notatus, Sept.; 5 Notropis whipplei, May, June.

Simulium, larvæ: 1 Eucalia inconstans, June; 1 Notropis atherinoides, Apr.; 2 N. whipplei, June.

Bibio albipennis: 1 Notropis atherinoides, May.

Culicidæ: 1 Alvarius punctulatus, May; 1 Lepomis cyanellus, yg.; 1 Aphredoderus sayanus, July; 1 Zygonectes notatus, June; 1 Clupea chrysochloris, $2\frac{1}{4}$ in., Sept.; 2 Notropis atherinoides, July; 1 Noturus gyrinus, Sept.

Culicidæ, larvæ: 2 Micropterus dolomiei, yg.; 1 M. salmoides, yg.; 1 Polyodon spathula, May.

Corethra, larva: 1 Pomoxys, Oct.; 1 yg.; 7 Aphredoderus sayanus, Aug., Sept.; 1 Dorosoma cepedianum, yg.; 2 Amiurus nebulosus, Aug.; 1 A. marmoratus, Oct.; 3 Polyodon spathula, May, Aug.

Chironomidæ: 3 Aplodinotus grunniens, yg.; 1 Roccus interruptus, yg.; 17 Labidesthes sicculus, June, Aug., Oct.; 2 Zygonectes notatus, Oct.; 1 Fundulus diaphanus, Oct.; 1 Phenacobius mirabilis, Oct.; 1 Notropis heterodon, May; 2 Ictiobus urus, Aug.

Chironomidæ, larvæ and pupæ: 3 Aplodinotus grunniens, yg.; 1 Roccus interruptus, yg.; 1 Roccus chrysops, Nov.; 2 yg.; 1 Perca lutea, May; 6 yg.; 8 Alvarius punctulatus, May, June; 3 Etheostoma fusiforme, July; 2 E. jessiæ, Sept.; 6 E. cœruleum, June, July, Aug.; 5 E. lineolatum, Apr., May, June, July; 2 E. zonale, June; 3 Hadropterus aspro, Aug.; 2 H. phoxocephalus, Apr., Aug.; 9 Percina caprodes, Apr., Aug., Sept.; 1 Boleosoma camurum; 9 B. maculatum, Apr., July, Aug.; 2 Crystallaria asprella, June; 3 Ammocrypta pellucida, June; 2 Micropterus dolomiei, yg.; 2 M. salmoides, yg.; 3 Lepomis gibbosus, May, July, Aug.; 13 yg.; 1 L. notatus, Sept.; 2 L. pallidus, July, Nov.; 11 yg.; 4 L. megalotis, June; 5 L. cyanellus, yg.; 4 Chænobryttus gulosus, yg.; 3 Ambloplites rupestris, yg.; 7 Pomoxys, Apr., May, Nov.; 13 yg.; 2 Centrarchus macropterus, July; 4 yg.; 8 Aphredoderus sayanus., Aug., Sept.; 1 Labidesthes sicculus, July; 5 Eucalia inconstans, June; 2 Fundulus diaphanus, Oct.; 2 Dorosoma cepedianum, $2\frac{1}{2}$–$5\frac{1}{4}$ in., July, Oct.; 1 yg.; 1 Hyodon tergisus, $2\frac{3}{4}$ in., June; 1 Cyprinidæ, yg.; 1 Notemigonus chrysoleucus, July; 3 Hybopsis biguttatus, June, Sept.; 9 Phenacobius mirabilis, Apr., Aug., Sept., Oct.; 3 Notropis, yg.; 5 N. whipplei, Apr., June, July; 1 N. hudsonius, May; 4 N. heterodon, Apr., July; 1 Campostoma anomalum, Sept.; 2 Placopharynx carinatus, Oct.; 1 Moxostoma, June; 1 yg.; 3 M. aureolum, Apr.; 7 M. macrolepidotum, May, Aug., Sept., Nov.; 3, $1\frac{1}{4}$–$2\frac{3}{4}$ in., July, Aug.; 2 Minytrema melanops, Oct.; 2 Erimyzon sucetta, $1\frac{3}{4}$–3 in., Oct.; 5 Hypentelium nigricans, Aug.; 10 yg.; 1 Catostomus teres, Oct.; 11 Ictiobus velifer, Mar., June, July,

Aug., Oct.; 14 I. bubalus, Apr., Aug., Sept., Oct.; 10 I. urus, July, Aug., Oct.; 6 I. cyprinella, June, July, Aug., Oct.; 12 Ictalurus punctatus, Apr., Aug., Sept.; 3, 2½–4 in., June, Sept.; 9 Amiurus, yg.; 5 A. natalis, 2–3½ in., July, Oct.; 3 A. nebulosus, Sept., Oct.; 2, 2½–3½ in., June, Aug.; 4 A. marmoratus, Oct.; 2 Noturus, yg.; 11 N. gyrinus, May, Aug., Sept., Oct.; 2 Amia calva, June, Sept.; 1 yg.; 5 Polyodon spathula, Aug., Sept., Nov.

Tipulidæ: 1 Coregonus artedi, Oct.; 1 Hyodon tergisus, Oct.; 1 Notropis atherinoides, Apr.

Tipulidæ, larvæ: 1 Notropis atherinoides, Apr.

Tipulidæ, eggs: 1 Coregonus artedi, Oct.; 1 Hyodon tergisus, Oct.

Tabanus, larvæ: 1 Ictalurus punctatus, Apr.; 1 Amiurus nebulosus, May.

Muscidæ: 1 Clupea chrysochloris, 2½ in., Sept.; 1 Hyodon tergisus, Oct.

Muscidæ, larvæ: 1 Micropterus dolomiei, yg.

COLEOPTERA.

Larvæ: 1 Roccus chrysops, Nov.; 1 Micropterus dolomiei, yg.; 1 Lepomis pallidus, July; 1 Ambloplites rupestris, yg.; 2 Pomoxys, Apr., May; 1 Notropis whipplei, June; 1 Ictiobus urus, July; 1 Noturus, yg.

Terrestrial: 3 Lepomis pallidus, July, Nov.; 1 Dorosoma cepedianum, July; 2 Hyodon tergisus, Oct.; 1 Semotilus atromaculatus, July; 1 Hybopsis biguttatus, Sept.; 1 Notropis atherinoides, May; 1 N. megalops, July; 1 N. whipplei, Aug.; 1 Moxostoma macrolepidotum, Aug.; 3 Hypentelium nigricans, Aug.; 1 Ictiobus bubalus, Oct.; 1 Amiurus marmoratus, Aug.; 1 Polyodon spathula, Nov.

Aquatic: 1 Hyodon tergisus, May.

Aquatic larvæ: 1 Aphredoderus sayanus, Oct.; 2 Hypentelium nigricans, Aug.; 1 Ictiobus cyprinella, July; 1 Noturus gyrinus, May.

Cicindelidæ: 1 Hyodon tergisus, Oct.

Carabidæ: 1 Lepomis pallidus, Nov.; 1 Notropis atherinoides, Apr.; 1 Ictalurus punctatus, Apr.; 1 Amiurus nebulosus, July.

Carabidæ, larvæ: 1 Ictiobus urus, July.
Clivina: 1 Hyodon tergisus, Aug.
Bembidium: 1 Notropis atherinoides, May.
Pterostichus sayi: 1 Hyodon tergisus, Oct.
Harpalini: 2 Lepomis pallidus, July, Nov.
Agonoderus pallipes: 1 Ambloplites rupestris, July; 1 Hyodon tergisus, Aug.; 1 Notropis atherinoides, Apr.; 1 Ictalurus punctatus, May.
Harpalus: 1 Semotilus atromaculatus, Sept.
Stenolophus: 1 Hyodon tergisus, Aug.
Anisodactylus discoideus: 1 Lepomis pallidus, Nov.; 1 Hyodon tergisus, Oct.
Haliplus: 1 Lepomis notatus, Sept.; 1 Semotilus atromaculatus, Aug.
Cnemidotus 12-punctatus: 1 Lepomis notatus, Sept.
Dytiscidæ: 1 Lepomis cyanellus, yg.; 1 Ambloplites rupestris, July.
Dytiscidæ, larvæ: 2 Micropterus dolomiei, yg.; 1 Lepomis pallidus, July; 1 Pomoxys, Apr.; 1 Ictalurus punctatus, Apr.; 1 Amiurus nebulosus, Oct.
Hydroporus undulatus: 1 Ambloplites, yg.
H. hybridus: 1 Lepomis notatus, Sept.
Coptotomus interrogatus: 1 Lepomis pallidus, July; 1 Polyodon spathula, May.
Cybister fimbriolatus: 1 Hyodon tergisus, Aug.
Gyrinidæ: 1 Amiurus nebulosus, Aug.
Gyrinidæ, larvæ: 1 Aplodinotus grunniens, Oct.; 3 yg.; 2 Lepomis pallidus, July, Nov.; 1 yg.; 1 L. megalotis, June; 4 Pomoxys, Apr., Nov.; 1 Notropis megalotis, Apr.; 1 Moxostoma macrolepidotum, Sept.
Hydrophilidæ: 2 Lepomis gibbosus, May, Aug.; 1 yg.; 1 Lepomis pallidus, May, July; 1 Fundulus diaphanus, Oct.; 1 Semotilus atromaculatus, Sept.
Hydrophilidæ, larvæ: 2 Aplodinotus grunniens, yg.: 1 Micropterus dolomiei, yg.; 1 Lepomis pallidus, July, Oct.; 2 Placopharynx carinatus, Oct.; 2 Moxostoma macrolepidotum; Sept.; 2 Ictiobus bubalus, Apr., Oct.; 1 Amiurus marmoratus, Aug.
Hydrophilus: 1 Lepomis cyanellus.

H. nimbatus: 1 Lepomis pallidus, July; 1 Ambloplites rupestris, July; 1 Hyodon tergisus, Oct.
H. glaber: 1 Hyodon tergisus, Oct.
Berosus striatus: 1 Hyodon tergisus, Oct.
Philhydrus: 3 Zygonectes notatus, Sept., Oct.
Silvanus: 1 Notropis atherinoides, Aug.
Histeridæ: 1 Hyodon tergisus, Oct.
Heterocerus: 1 Coregonus artedi, Oct.
H. undatus: 1 Ictiobus urus, July.
Staphylinidæ: 1 Lepomis cyanellus, yg.; 2 Zygonectes notatus, Oct.; 1 Fundulus diaphanus, Oct.; 1 Coregonus artedi, 6 in., Aug.; 1 Ictalurus punctatus, May.
Staphylinus tomentosus: 1 Ictalurus punctatus, Oct.
Elateridæ: 1 Lepomis pallidus, July; 1 Zygonectes notatus, July.
Drasterius elegans: 1 Hyodon tergisus, Aug.
Lampyridæ: 1 Hyodon tergisus, Oct.
Scarabæidæ: 1 Lepomis pallidus, Nov.; 1 Semotilus atromaculatus, July; 1 Notropis atherinoides, Apr.; 1 N. megalops, July.
Aphodius fimetarius: 1 Lepomis pallidus, May; 1 Hyodon tergisus, Oct.
A. inquinatus: 1 Lepomis pallidus, Nov.; 1 Notropis atherinoides, Oct.; 1 Polyodon spathula, Nov.
Melolonthinæ: 1 Notemigonus chrysoleucus, July.
Anomala binotata: 1 Chænobryttus gulosus.
Chalepus trachypygus: 2 Hyodon tergisus, Oct.
Tetramera: 1 Dorosoma cepedianum, July.
Chrysomelidæ: 1 Lepomis pallidus, Nov.; 1 L. megalotis, June; 1 Semotilus atromaculatus, July.
Cryptocephalus 4-maculatus: 1 Lepomis pallidus, Nov.
Colaspis brunnea: 1 Hyodon tergisus, Aug.
Doryphora 10-lineata: 1 Lepomis pallidus, Nov.
Diabrotica 12-punctata: 2 Lepomis pallidus, Nov.
D. vittata: 1 Coregonus artedi, Oct.
D. longicornis: 1 Hyodon tergisus, Aug.
Halticini: 1 Lepomis pallidus, Nov.
Disonycha limbicollis: 1 Hyodon tergisus, Oct.
Anthicidæ: 1 Coregonus artedi, 6 in., Aug.

Rhynchophora: 1 Notropis megalops, July; 2 N. hudsonius, May.

R. brevirostres: 1 Notropis hudsonius, May.

Curculionidæ: 1 Lepomis pallidus, Nov.

Macrops: 2 Hyodon tergisus, Aug., Oct.

Sphenophorus ochreus: 1 Hyodon tergisus, Oct.

HEMIPTERA.

Terrestrial: 1 Coregonus artedi, Oct.; 2 Notropis megalops, June, Aug.; 1 Ictiobus cyprinella, Oct.

Aquatic: 1 Zygonectes notatus, Oct.; 1 Notemigonus chrysoleucus, Sept.; 1 Notropis atherinoides, July; 1 N. hudsonius, May; 1 Hypentelium nigricans, yg.

Heteroptera: 1 Micropterus salmoides, yg.; 1 Zygonectes notatus, Sept.; 1 Fundulus diaphanus, Oct.; 1 Notropis atherinoides, May.

Terrestrial Heteroptera: 1 Fundulus diaphanus, Oct.; 1 Hyodon tergisus, Oct.

Amnestus: 1 Coregonus artedi, 6 in., Aug.

Pentatomidæ: 1 Lepomis pallidus, Nov.; 1 Hyodon tergisus, Oct.; 1 Ictalurus punctatus, May.

Podisus: 1 Ictalurus punctatus, Apr.

Euschistus: 1 Ictalurus punctatus, Oct.

Coreidæ: 1 Pomoxys, June.

Lygæidæ: 1 Gambusia patruelis, Sept.

Lygus pratensis: 1 Coregonus artedi, Oct.

Triphleps insidiosus: 1 Clupea chrysochloris, $2\frac{1}{4}$ in., Sept.

Tingitidæ: 1 Zygonectes notatus, Sept.

Piesma: 1 Notropis whipplei, Aug.

Tingis: 2 Zygonectes notatus, Sept.

Coriscus ferus: 1 Zygonectes notatus, Sept.; 1 Hyodon tergisus, Aug.

Melanolestes picipes: 1 Hyodon tergisus, Oct.

Hygrotrechus: 1 Ambloplites rupestris, yg.

Zaitha fluminea: 1 Micropterus salmoides, Nov.; 2 Hyodon tergisus, Oct.

Nepa: 1 Lepomis pallidus, May.

Ranatra: 1 Lepomis pallidus, July.

Notonecta: 1 Micropterus salmoides, yg.

Plea: 1 Gambusia patruelis, Sept.; 1 Ictalurus punctatus, May.

Corisa: 2 Perca lutea, yg.; 2 Hadropterus aspro, Aug.; 2 Percina caprodes, July, Sept.; 6 Micropterus dolomiei, yg.; 5 M. salmoides, yg.; 4 Lepomis pallidus, June, July, Nov.; 4 yg.; 1 Lepomis megalotis, June; 5 L. cyanellus, yg.; 1 Chænobryttus gulosus, Oct.; 1 yg.; 1 Ambloplites rupestris, yg.; 4 Pomoxys, Apr., May.; 4 yg.; 1 Centrarchus irideus, yg.; 3 Aphredoderus sayanus, July, Sept.; 1 Esox vermiculatus, 4 in., June; 1 Zygonectes dispar, July; 2 Z. notatus, Sept., Oct.; 1 Dorosoma cepedianum July; 3 Semotilus atromaculatus, July, Sept.; 1 Notropis megalops, Aug.; 1 N. whipplei, July; 2 Ictiobus urus, July, Aug.; 2 I. cyprinella, July; 1 Ictalurus punctatus, Apr.; 1 Amiurus nebulosus, Oct.; 1 Amia calva, June; 1 yg.; 1 Polyodon spathula, Aug.

C. alternata: 1 Perca lutea, yg.; 3 Micropterus salmoides, yg.; 1 Pomoxys, Apr.; 3 Zygonectes notatus, Sept.; 1 Ictalurus punctatus, Apr.; 1 Polyodon spathula, May.

C. signata: 4 Micropterus dolomiei, yg.

C. tumida: 2 Perca lutea, yg.; 1 Hadropterus aspro, Aug.; 8 Micropterus dolomiei, yg.; 3 M. salmoides, yg.; 1 Lepomis pallidus, Nov.; 1 L. megalotis; 1 L. cyanellus; 1 yg.; 1 Chænobryttus gulosus; 2 yg.; 3 Ambloplites rupestris, yg.; 1 Pomoxys, July; 1 yg.; 1 Centrarchus irideus, July; 1 Hyodon tergisus, $2\frac{3}{8}$ in., June; 1 Amiurus nebulosus, $3\frac{1}{2}$ in., June.

Homoptera: 1 Gambusia patruelis, Sept.; 1 Coregonus artedi, Oct.; 1, 6 in., Aug.; 1 Hyodon tergisus, Oct.; 2 Notropis whipplei, Apr., Aug.; 1 Ictalurus punctatus, May.

Tettigoninæ: 1 Labidesthes sicculus, Oct.; 1 Zygonectes notatus, Oct.

Diedrocephala mollipes: 1 Coregonus artedi, Oct.

Typhlocyba: 1 Coregonus artedi, 2 in., Aug.; 1 Clupea chrysochloris, $2\frac{1}{4}$ in., Sept.

Aphididæ: 1 Gambusia patruelis, Sept.; 3 Zygonectes notatus, Sept., Oct.; 1 Notropis, yg.; 3 N. atherinoides, July, Aug.

Aphis: 1 Labidesthes sicculus, Oct.; 1 Zygonectes notatus, Oct.

Thrips: 1 Labidesthes sicculus, Oct.; 1 Zygonectes notatus, Oct.; 1 Fundulus diaphanus, Oct.; 1 Moxostoma, yg.

ORTHOPTERA.

Undetermined: 1 Hyodon tergisus, 2⅞ in., June; 1 Amiurus marmoratus, Aug.

Acrididæ: 1 Roccus interruptus, May; 3 Semotilus atromaculatus, Sept.; 2 Ictalurus punctatus, Oct.

Tettiginæ: 1 Ictalurus punctatus, June.

Tettix: 1 Hyodon tergisus, Oct.; 1 Ictalurus punctatus, Oct.

Tettigidea: 1 Lepomis pallidus, June, Nov.

Locustidæ: 1 Lepomis pallidus, May; 2 Semotilus atromaculatus, Sept.

Phaneroptera curvicauda: 1 Lepomis pallidus, Nov.

Nemobius vittatus: 1 Lepomis pallidus, Nov.

Blatta: 1 Ictalurus punctatus, June.

NEUROPTERA.

Larvæ: 2 Roccus chrysops, yg.; 1 Lepomis gibbosus, June; 1 L. pallidus, yg.; 1 Chænobryttus gulosus, yg.; 1 Ambloplites rupestris, yg.; 1 Aphredoderus sayanus, July; 1 Semotilus atromaculatus, May; 2 Hybopsis biguttatus, Aug., Sept.; 1 Phenacobius mirabilis, Oct.; 5 Notropis megalops, May, June; 2 N. whipplei, Apr., July; 1 Moxostoma macrolepidotum, Sept.; 1 Ictiobus velifer; 1 I. cyprinella, July.

Terrestrial: 1 Ictiobus urus, Aug.

Phryganeidæ: 1 Lepomis pallidus, July; 1 Ambloplites rupestris, July; 1 Ictiobus bubalus, Oct.; 1 I. urus, Aug.

Phryganeidæ, larvæ: 2 Perca lutea, May; 2 Etheostoma cœruleum, June; 1 Percina caprodes, Apr.; 2 Lepomis gibbosus, May; 1 L. megalotis, July; 4 Hybopsis biguttatus, Aug., Sept.; 1 Phenacobius mirabilis, Apr.; 3 Notropis atherinoides, July, Aug.; 4 N. megalops, Apr. June; 1 N. stramineus, Apr.; 3 Ictiobus velifer, Aug., Oct.; 5 I. bubalus, Aug., Oct.; 7 Ictalurus punctatus, Apr., May, Aug.; 1 Amiurus nebulosus, May; 1 Noturus gyrinus, May; 3 Polyodon spathula, June, Aug., Sept.

Leptoceridæ, larvæ: 1 Gambusia patruelis, Sept.; 1 Ictalurus punctatus, Oct.

Leptocerus, larvæ: 1 Lepomis gibbosus, July; 1 Ictiobus bubalus, Oct.

Sialidæ, larvæ: 1 Ictiobus cyprinella, July; 1 Ictalurus punctatus, Aug.; 1 Amiurus nebulosus, Oct.; 2 A. mamoratus, Oct.

Sialis infumata: 3 Lepomis pallidus, May, Aug.

Corydalis, larvæ: 1 Lepomis cyanellus, Apr.; 1 Ictiobus cyanellus, Aug.

Corydalis cornutus, larvæ: 1 Pomoxys, Oct.

Odonata, larvæ: 1 Labidesthes sicculus, July; 4 Esox vermiculatus, June, Oct.; 1, 4 in., June; 1 Polyodon spathula, May.

Libellulinæ, larvæ: 4 Aplodinotus grunniens, Sept.; 5 Perca lutea, Mar., May; 2 Lepomis gibbosus, May; 5 L. pallidus, May, Oct.; 1 L. cyanellus, Apr.; 1 yg.; 1 Ambloplites rupestris, July; 1 Pomoxys, May; 1 Aphredoderus sayanus, Oct.; 1 Esox lucius, Aug.; 1 E. vermiculatus, $2\frac{3}{4}$ in., June; 2 Ictiobus bubalus, Aug., Oct.; 1 I. urus, Aug.; 6 Ictalurus punctatus, Mar., Apr., May, Sept.; 2 Amiurus nebulosus, May; 2 Amia calva, May, Aug.

Agrioninæ, larvæ: 3 Perca lutea, Mar., May; 1 yg.; 1 Hadropterus aspro, Aug.; 2 Micropterus dolomiei, yg.; 1 M. salmoides, Nov.; 2 Lepomis gibbosus, yg.; 3 L. pallidus, May, June, July; 1 yg.; 3 Chænobryttus gulosus, yg.; 1 Ambloplites rupestris, July; 9 Pomoxys, Mar., April, May; 1 Erimyzon sucetta, yg,; 2 Ictalurus punctatus, Mar., Apr.

Agrion, larvæ: 1 Roccus interruptus, May; 1 Labidesthes sicculus, June; 3 Esox vermiculatus, June, July; 1, $2\frac{3}{4}$ in., June; 1 Zygonectes notatus, Sept.; 1 Moxostoma, June; 1 M. macrolepidotum, Aug.; 1 Ictiobus bubalus, Oct.; 2 Ictalurus punctatus, Apr.; 1 Polyodon spathula, May.

Ephemeridæ: 1 Roccus interruptus, May.

Ephemeridæ, larvæ: 1 Aplodinotus grunniens, yg.; 5 Roccus chrysops, Nov.; 2 Perca lutea, May; 3 yg.; 1 Alvarius punctulatus, May; 3 Etheostoma fusiforme, July; 2 E. jessiæ, Sept.; 2 E. cœruleum, July, Aug.; 4 E. lineolatum, Apr., June; 6 Hadropterus aspro, July, Aug.; 5 H. phoxocephalus, Apr., Aug.; 1 Percina caprodes, July, Aug.; 1 Boleosoma camurum; 1 B. maculatum,

Aug.; 2 Ammocrypta pellucida, June; 3 Micropterus dolomiei, yg.; 3 M. salmoides, yg.; 1 Lepomis gibbosus, Aug.; 5 yg.; 2 L. pallidus, July, Aug.; 3 yg.; 1 L. megalotis, July; 3 L. cyanellus, Apr.; 5 yg.; 2 Chænobryttus gulosus, yg.; 2 Ambloplites rupestris, July; 3 Pomoxys, Mar., Apr.; 2 yg.; 2 Centrarchus irideus, July; 1 yg.; 3 Aphredoderus sayanus, July, Sept., Oct.; 2 Fundulus diaphanus, Oct.; 2 Hyodon tergisus, June; 1 Hybopsis biguttatus, June; 3 Notropis atherinoides, Apr., Aug., Oct.; 1 N. megalops, July; 2 N. whipplei, June; 1 N. hudsonius, Aug.; 2 N. stramineus, July; 1 N. heterodon, Sept.; 2 Moxostoma macrolepidotum, Aug., Sept.; 2 Hypentelium nigricans, Aug.; 1 yg.; 3 Ictiobus bubalus, Apr., Oct.; 3 I. urus, June, Aug.; 1 I. cyprinella, July; 13 Ictalurus punctatus, Mar., Apr., May, Aug.; 1, $2\frac{3}{4}$ in., Oct.; 1 Amiurus natalis, $3\frac{1}{2}$ in., Oct.; 1 Amiurus nebulosus, 2 in., Aug.; 1 Noturus, yg.; 6 N. gyrinus, May, Oct.; 1 Amia calva, June; 4 Polyodon spathula, May, June, Aug., Sept.

Cænis, larvæ: 2 Placopharynx carinatus, Oct.; 5 Hypentelium nigricans, Aug.; 1 Polyodon spathula, May.

Baëtis, larvæ: 1 Lepomis pallidus, June; 1 Ambloplites rupestris, July.

Hexagenia, larvæ: 15 Aplodinotus grunniens, June, Sept., Oct.; 4 yg.; 1 Roccus interruptus, Oct.; 2 R. chrysops, Sept., Oct.; 1 Perca lutea, Oct.; 4 yg.; 1 Hadropterus phoxocephalus, Aug.; 1 Lepomis gibbosus, May; 2 L. pallidus, Nov.; 1 L. cyanellus, Apr.; 2 Chænobryttus gulosus, Oct.; 18 Pomoxys, Mar., Apr., June, July, Oct., Nov.; 3 Aphredoderus sayanus, Sept.; 1 Esox vermiculatus, July; 3 Hyodon tergisus, Aug., Oct.; 1 Notropis megalops, Aug.; 2 N. hudsonius, June, Aug.; 1 Hypentelium nigricans, Aug.; 1 Ictiobus urus, Nov.; 2 I. cyprinella, Aug.; 7 Ictalurus punctatus, Apr., Oct.; 1, 4 in., Sept.; 4 Amiurus natalis, Oct., Nov.; 4 A. nebulosus, May, Oct.; 7 A. marmoratus, Oct., Nov.; 4 Polyodon spathula, May, June, Sept., Nov.

THYSANURA.

Podura: 3 Labidesthes sicculus, Aug., Oct.

ARACHNIDA.

Undetermined: 1 Hyodon tergisus, Oct.
Araneina: 4 Lepomis pallidus, Oct., Nov.; 2 Labidesthes sicculus, June, Oct.; 1 Eucalia inconstans; 3 Zygonectes notatus, June, Oct.; 1 Fundulus diaphanus, Oct.; 1 Dorosoma cepedianum, July; 1 Clupea chrysochloris, $2\frac{1}{4}$ in., Sept.; 1 Hyodon tergisus, Oct.; 1 Notropis atherinoides, Apr.; 1 N. whipplei, Apr.; 1 Ictalurus punctatus, Oct.; 1 Amiurus natalis, Oct.; 2 A. marmoratus, Nov.
Terrestrial Araneina: 3 Labidesthes sicculus, Aug., Oct.
Acarina: 2 Umbra limi, July; 1 Fundulus diaphanus, Oct.; 1 Notemigonus chrysoleucus, July; 1 Notropis megalops, Aug.; 2 N. heterodon, May, July; 1 Ictiobus urus, Aug.; 1 I. cyprinella, Oct.
Hydrachnidæ: 1 Lepomis pallidus, July, Nov.; 5 yg.; 1 Centrarchus irideus, yg.; 1 Labidesthes sicculus, June; 1 Umbra limi, July; 1 Dorosoma cepedianum, July; 2 Moxostoma macrolepidotum, $2\frac{1}{2}$–$2\frac{3}{4}$ in., Aug.; 2 Erimyzon sucetta, yg.; 1 Hypentelium nigricans, yg.; 1 Catostomus teres, Aug.; 1 Ictiobus bubalus, Oct.; 2 I. cyprinella, July; 1 Polyodon spathula, Aug.
Hydrachna: 1 Ambloplites rupestris, July.
Atax: 1 Lepomis pallidus, yg.

CRUSTACEA.

DECAPODA.

Cambarus: 1 Perca lutea, May; 1 Lepomis pallidus, Nov.; 1 L. cyanellus; 2 Ambloplites rupestris, July; 3 Semotilus atromaculatus; 2 Hybopsis biguttatus, Sept., Nov.; 1 Ictiobus urus, Aug.; 3 Ictalurus punctatus, Apr., May, June; 4 Amiurus natalis, May, Aug.; 6 A. nebulosus, May, Aug.; 1, $3\frac{1}{2}$ in., June; 11 Amia calva, Apr., May, June; 1 Lepidosteus platystomus, Apr.
C. virilis: 2 Perca lutea, May; 1 Anguilla rostrata, Aug.; 4 Amia calva, May.

C. propinquus: 3 Lota maculosa, Nov.; 2 Micropterus dolomiei, June.
C. immunis: 1 Micropterus salmoides, Oct.
C. obesus: 1 Amia calva, Apr.
Palæmonetes exilipes: 1 Perca lutea; 1 Lepomis cyanellus; 1 Amiurus natalis, 2 in., July.

AMPHIPODA.

Gammarus, yg.: 2 Alvarius punctulatus.
Gammarus fasciatus: 1 Micropterus dolomiei, yg.
Crangonyx: 1 Alvarius punctulatus, June; 1 Ictiobus cyprinella, July; 1 Amia calva, June.
C. gracilis: 1 Umbra limi, Sept.; 1 Gambusia patruelis, Sept.; 1 Zygonectes notatus, June.
Allorchestes dentata: 1 Roccus interruptus, May; 7 Perca lutea, Mar., May, Aug.; 4 yg,; 1 Percina caprodes, Aug.; 5 Micropterus dolomiei, yg.; 2 Lepomis gibbosus, Aug.; 3 yg.; 8 L. pallidus, May, June, July, Aug.; 1 yg.; 2 L. megalops, June; 1 Ambloplites rupestris, yg.; 1 Centrarchus irideus, yg.; 1 Aphredoderus sayanus, Oct.; 1 Esox vermiculatus, yg.; 6 Fundulus diaphanus, June, Oct.; 1 Notropis megalops, May; 1 N. heterodon, May; 1 Placopharynx carinatus, Oct.; 1 Ictiobus velifer, Oct.; 1 Ictalurus punctatus, May; 1, 4 in., June; 2 Amiurus, yg.; 1 A. natalis, 2½ in., July; 3 A. nebulosus, May; 9 Noturus gyrinus, May, Aug., Oct.; 1 Amia calva, June; 1 Polyodon spathula, May.

ISOPODA.

Asellus: 2 Uranidea richardsoni, Aug.; 1 Aplodinotus grunniens, Apr.; 1 Roccus chrysops; 3 Perca lutea, Mar., Aug.; 1 yg.; 2 Micropterus dolomiei, yg.; 2 Lepomis gibbosus, May, Aug.; 4 L. pallidus, May, Aug.; 1 L. megalotis, June; 1 L. cyanellus, yg.; 2 Aphredoderus sayanus, July, Aug.; 1 Esox vermiculatus, July; 1 Amiurus nebulosus, 3½ in., June; 2 Noturus gyrinus, June, Aug.; 1 Amia calva, June.
Mancasellus tenax: 3 Perca lutea, Mar.; 1 yg.

Entomostraca.

Eggs: 1 Dorosoma cepedianum, Oct.

CLADOCERA.

Daphnella: 1 Percina caprodes, Sept.; 1 Pomoxys, yg.; 1 Notropis heterodon, July; 1 Ictiobus cyprinella, July.

Daphniidæ: 1 Roccus interruptus; yg.; 1 Stizostedion vitreum, yg.; 5 Perca lutea, yg.; 2 Percina caprodes, Aug.; 4 Centrarchinæ, yg.; 1 Micropterus dolomiei, yg.; 4 M. salmoides, yg.; 2 Lepomis gibbosus, yg.; 2 L. pallidus, yg.; 3 L. cyanellus, yg.; 1 Ambloplites rupestris, yg.; 2 Pomoxys, Mar.; 4 yg.; 1 Eucalia inconstans, June; 2 Zygonectes notatus, June; 1 Dorosoma cepedianum, June; 1 Notemigonus chrysoleucus, Sept.; 1 Notropis atherinoides, Oct.; 1 N. whipplei, Aug.; 1 Hypentelium nigricans, yg.; 1 Ictiobus urus, Aug.; 1 Amiurus, yg.; 2 Polyodon spathula, Aug.

Daphniidæ, eggs: 1 Ictiobus urus, Aug.; 1 Polyodon spathula, Aug.

Daphnia: 3 Perca lutea, yg.; 1 Percina caprodes, Aug.; 1 Centrarchinæ, yg.; 2 Chænobryttus gulosus, yg.; 1 Zygonectes notatus, Sept.; 1 Dorosoma cepedianum, $5\frac{1}{4}$ in., Oct.; 3 yg.; 1 Ictiobus velifer, yg.; 1 Ictalurus punctatus, 4 in., June; 1 Amiurus natalis, $2\frac{5}{8}$ in., Oct.; 1 A. nebulosus, $3\frac{1}{2}$ in., June.

Daphnia, eggs: 1 Coregonus artedi.

D. pulex: 1 Perca lutea, yg.; 1 Lepomis pallidus, yg.; 1 Labidesthes sicculus, Aug.; 1 Dorosoma cepedianum, yg.; 2 Notemigonus chrysoleucus, July; 1 Polyodon spathula, June.

D. hyalina: 4 Labidesthes sicculus, June, Aug.

D. retrocurva: 3 Labidesthes sicculus, June.

Simocephalus: 3 Lepomis gibbosus, yg.; 3 L. pallidus, yg.; 3 Chænobryttus gulosus, yg.; 4 Pomoxys, Mar., Apr.; 3 yg.; 2 Notropis heterodon, May, July; 1 Ictiobus velifer, Mar.; 3 Ictiobus urus, Apr., Aug.; 2 I. cyprinella, Apr.; 3 Amiurus, yg.; 2 Notropis gyrinus, Oct.

Simocephalus, eggs: 1 Ictiobus urus, Aug.

S. vetulus: 1 Pomoxys, Mar.

S. americanus: 1 Perca lutea, yg.; 1 Alvarius punctulatus, May; 3 Micropterus salmoides, yg.; 1 Lepomis cyanellus, yg.; 4 Pomoxys, yg.; 1 Centrarchus irideus, yg.; 1 Labidesthes sicculus, Aug.; 1 Esox vermiculatus, yg.; 1 Dorosoma cepedianum, yg.; 1 Ictiobus velifer, Apr.; 2 Amiurus, yg.; 1 A. natalis, 3½ in., Oct.; 1 Amia calva, June; 1 yg.

Ceriodaphnia: 1 Ictiobus urus, Aug.; 1 Amiurus, yg.

C. dentata: 1 Dorosoma cepedianum, yg.

Scapholeberis: 1 Amia calva, yg.

S. mucronatus: 1 Erimyzon sucetta, yg.; 1 Ictiobus velifer, yg.; 2 Amiurus, yg.; 1 A. nebulosus, 3½ in., June; 1 Amia calva, June; 1 Lepidosteus platystomus, yg.

Macrothrix laticornis: 1 Boleosoma maculatum, July; 3 Amiurus, yg.; 2 A. natalis, 2½ in., July.

Bosmina: 2 Perca lutea, yg.; 1 Centrarchinæ, yg.; 4 Lepomis pallidus, May; 2 Chænobryttus gulosus, yg.; 1 Pomoxys, June; 1 yg.; 5 Labidesthes sicculus. June, Aug. Oct.; 1 Eucalia inconstans, June; 1 Coregonus artedi; 1 Dorosoma cepedianum, 5¼ in., Oct.; 8 yg.; 1 Cyprinidæ, yg.; 2 Notemigonus chrysoleucus, Sept.; 2 Notropis atherinoides, Nov.; 2 Ictiobus, yg.; 3 I. velifer, Mar., Sept., Oct.; 2 I. bubalus, Oct.; 2 I. urus, Oct.; 4 I. cyprinella, Apr., May, Oct.; 5 Polyodon spathula, May, June, Aug.

B. longirostris: 4 Micropterus salmoides, yg.; 2 Dorosoma cepedianum, yg.; 2 Notropis atherinoides, Oct.

Iliocryptus: 1 Notropis heterodon; July; 1 Ictiobus bubalus, Sept.

Lynceidæ: 1 Perca lutea, yg.; 1 Alvarius punctulatus, May; 1 Chænobryttus gulosus, yg.; 1 Labidesthes sicculus, June; 1 Umbra limi, Sept.; 1 Zygonectes dispar, July; 4 Z. notatus, June, Sept., Oct.; 1 Moxostoma, yg.; 1 M. macrolepidotum, Sept.; 1 Erimyzon sucetta, 1¾ in.; 1 Ictiobus velifer, Oct.; 2 I. bubalus, Sept., Oct.; 3 I. cyprinella, Apr.

Chydorus: 3 Perca lutea, yg.; 4 Alvarius punctulatus, May; 1 Centrarchinæ, yg.; 1 Micropterus salmoides, yg.; 5 Lepomis gibbosus, yg.; 3 L. cyanellus, yg.; 1 Chænobryttus gibbosus; 1 yg.; 8 Pomoxys, yg.; 1 Labidesthes sicculus, Oct.; 6 Eucalia inconstans, June; 1 Esox vermiculatus, yg.; 1 Umbra limi, Sept.; 2 Zygonectes notatus, Sept., Oct.;

2 Fundulus diaphanus, Oct.; 2 Dorosoma cepedianum, yg.; 1 Notemigonus chrysoleucus, Sept.; 2 Notropis atherinoides, Oct.; 1 N. megalops, May; 1 N. whipplei; 5 N. hudsonius, June, July; 10 N. heterodon, May, July, Sept.; 2 Erimyzon sucetta, yg.; 1 Carpiodes, Apr.; 1 Ictiobus urus, Aug.; 2 I. cyprinella, July; 2 Amiurus, yg.; 1 A. nebulosus, May; 1, 2 in., Aug.; 3 Noturus gyrinus, Oct.; 1 Amia calva, June; 1 yg.; 1 Polyodon spathula, May.

C. denticulatus: 1 Pomoxys, yg.

C. sphericus: 1 Coregonus artedi.

Pleuroxus: 1 Perca lutea, yg.; 2 Micropterus salmoides, yg.; 1 Lepomis gibbosus, yg.; 2 L. pallidus, yg.; 2 L. cyanellus, yg.; 1 Chænobryttus gulosus, yg.; 1 Ambloplites rupestris, yg.; 2 Pomoxys, yg.; 1 Labidesthes sicculus, Oct.; 1 Zygonectes notatus, Sept.; 1 Notropis heterodon, Sept.; 4 Moxostoma macrolepidotum, 2⅛–2¾ in., Aug.; 2 Erimyzon sucetta, yg.; 1 Ictiobus cyprinella, July; 1 Amiurus, yg.; 3 Noturus gyrinus, Oct.

P. dentatus: 1 Lepomis pallidus, yg.; 1 Notropis heterodon, July; 2 Amiurus, yg.

Alona: 1 Lepomis pallidus, Aug.; 3 yg.; 1 Pomoxys, yg.; 1 Centrarchus irideus, yg.; 1 Labidesthes sicculus, Oct.; 3 Umbra limi, Sept.; 3 Fundulus diaphanus, Oct.. 2 Dorosoma cepedianum, July; 1 yg.; 1 Notropis hudsonius, June; 4 N. heterodon, May, July; 1 Moxostoma, yg.; 1 M. macrolepidotum, Sept.; 1 Erimyzon sucetta, yg.; 7 Hypentelium nigricans, yg.; 2 Catostomus teres, June, Aug.; 3 Carpiodes, Apr., July, Oct.; 1 Ictiobus bubalus, Apr.; 2 I .cyprinella, July; 3 Amiurus yg.; 1 Noturus gyrinus, Oct.

Acroperus: 1 Notropis heterodon, May.; 2 Ictiobus cyprinella, July; 3 Amiurus natalis, 2–2⅛in., July.

A. leucocephalus: 1 Zygonectes notatus, Oct.; 1 Fundulus diaphanus, Oct.; 1 Notropis megalops, Aug.; 1 N. heterodon, May.

Camptocercus macrurus: 2 Fundulus diaphanus, Oct.

Eurycercus: 1 Pomoxys, yg.; 1 Labidesthes sicculus, June; 1 Fundulus diaphanus, June; 1 Polyodon spathula, May.

Eurycercus lamellatus: 1 Percina caprodes, Aug.; 1 Micropterus salmoides, yg.; 2 Lepomis pallidus, yg.; 1 Amiurus, yg.

Leptodora: 1 Roccus interruptus, yg.; 1 Micropterus salmoides, yg.; 1 Dorosoma cepedianum, yg.; 1 Hyodon tergisus, June; 1 Amiurus nebulosus, Aug.; 1 Polyodon spathula, Aug.

OSTRACODA.

Cypridæ: 1 Stizostedion vitreum, yg.; 1 Alvarius punctulatus; 1 Percina caprodes, Aug.; 1 Centrarchinæ, yg.; 8 Lepomis gibbosus, yg.; 2 L. pallidus, July, Aug.; 2 yg.; 1 L. cyanellus, yg.; 3 Centrarchus irideus, yg.; 1 Notropis heterodon, July; 3 Moxostoma, yg.; 2 M. macrolepidotum, $1\frac{1}{4}$–$2\frac{3}{4}$ in., July, Aug.; 1 Erimyzon sucetta, $1\frac{3}{4}$ in.; 1 yg.; 1 Hypentelium nigricans, yg.; 4 Carpiodes, Mar., Apr., Aug.; 2 yg.; 2 Ictiobus cyprinella, July; 2 Amiurus, yg.; 3 A. natalis, 2–$2\frac{1}{8}$ in., July.

Cypris: 3 Perca lutea, yg.; 1 Percina caprodes, Aug.; 1 Lepomis pallidus, May; 1 yg.; 1 L. cyanellus, yg.; 1 Pomoxys, Apr.; 1 yg.; 1 Centrarchus irideus, yg.; 2 Aphredoderus sayanus, Sept.; 1 Eucalia inconstans, Oct.; 6 Umbra limi, Sept.; 2 Zygonectes notatus, Sept., Oct.; 3 Fundulus diaphanus, Oct.; 4 Dorosoma cepedianum, Apr., July, Oct.; 1 yg.; 1 Notemigonus chrysoleucus, Sept.; 1 Notropis megalops, Aug.; 4 N. heterodon, May, July, Sept.; 1 Pimephales notatus, Sept.; 1 Moxostoma, yg.; 1 M. macrolepidotum, 2 in., July; 1 Minytrema melanops, Oct.; 1 Catostomus teres, Aug.; 1 Carpiodes, June; 5 Ictiobus bubalus, Apr., Oct.; 3 I. urus, Aug., Oct.; 3 I. cyprinella, Apr., June; 1 Amiurus, yg.; 1 A. natalis, $2\frac{1}{8}$ in., July; 3 Noturus gyrinus, May, Aug.; 2 Polyodon spathula, June, Aug.

C. vidua: 1 Eucalia inconstans; 1 Fundulus diaphanus, Oct.; 2 Notropis hudsonius, July.

Candona: 1 Fundulus diaphanus, Oct.; 1 Noturus gyrinus.

C. bifasciata: 2 Amiurus, yg.

COPEPODA.

Nauplius: 1 Erimyzon sucetta, yg.

Cyclops: 1 Aplodinotus grunniens, yg.; 2 Roccus interruptus, yg.; 7 Perca lutea, yg.; 8 Alvarius punctulatus, May, June;

1 Etheostoma lineolatum, July; 2 Hadropterus aspro, Aug.; 1 Percina caprodes, July; 3 Boleosoma maculatum, July, Aug.; 4 Centrarchinæ, yg.; 1 Micropterus dolomiei, yg.; 8 M. salmoides, yg.; 13 Lepomis pallidus, yg.; 5 L. cyanellus, yg.; 4 Chænobryttus gulosus, yg.; 2 Ambloplites rupestris, yg.; 3 Pomoxys, Apr., June; 15 yg.; 2 Centrarchus irideus, July; 4 yg.; 3 Aphredoderus sayanus, Aug., Sept.; 3 Eucalia inconstans; 1 Gambusia patruelis, Sept.; 2 Zygonectes notatus, Sept., Oct.; 1 Coregonus artedi; 1 Dorosoma cepedianum, July; 1, $5\frac{1}{4}$ in., Oct.; 10 yg.; 4 Notemigonus chrysoleucus, July, Sept.; 2 Semotilus atromaculatus, July; 1 Phenacobius mirabilis, Sept.; 2 Notropis whipplei, June; 1 N. stramineus, Apr.; 12 N. heterodon, Apr., May, July, Sept.; 1 Moxostoma, yg.; 1 M. macrolepidotum, Sept.; 2, $2\frac{1}{2}$–$2\frac{3}{4}$ in., Aug.; 1 Minytrema melanops, Oct.; 1 Erimyzon sucetta, $1\frac{3}{4}$ in.; 3 Hypentelium nigricans, yg.; 1 Catostomus teres, June; 8 Carpiodes, Mar., Apr., July, Aug., Oct.; 2 yg.; 10 Ictiobus bubalus, Apr., Sept., Oct.; 1 yg.; 3 I. urus, Apr., Aug., Oct.; 4 I. cyprinella, Apr., June, July; 11 Amiurus, yg.; 2 A. natalis, 2–$2\frac{1}{8}$ in., July; 2 A. nebulosus, 2–$3\frac{1}{2}$ in., June, Aug.; 2 Noturus, yg.; 6 N. gyrinus, Oct.; 1 Amia calva, June; 1 yg.; 3 Polyodon spathula, June, Aug.

C. thomasi: 1 Labidesthes sicculus, Aug.

Canthocamptus: 1 Labidesthes sicculus, Oct.; 1 Notropis stramineus, Apr.; 1 N. heterodon, May; 1 Erimyzon sucetta, 3 in., Oct.; 1 Hypentelium nigricans, yg.; 6 Carpiodes, Mar., Apr., June, Oct.; 1 yg.; 10 Ictiobus bubalus, Apr., Oct.; 1 I. urus, Oct.; 1 I. cyprinella, Oct.; 2 Noturus gyrinus, Oct.; 1 Polyodon spathula, May.

Diaptomus: 1 Perca lutea, yg.; 1 Labidesthes sicculus, Aug.; 1 Notropis atherinoides, Nov.; 1 N. heterodon, July; 1 Amiurus nebulosus, Aug.

Epischura lacustris: 3 Labidesthes sicculus, June, Aug.

Limnocalanus: 1 Labidesthes sicculus, Aug.

VERMES.

Polyzoa: 3 Lepomis pallidus, May, Aug., Oct.; 1 Pomoxys, yg.

Pectinatella magnifica: 1 Lepomis pallidus, yg.; 7 Ictiobus bubalus, Oct.

Plumatella: 1 Placopharynx carinatus, Oct.; 3 Ictiobus bubalus, Oct.; 1 I. cyprinella, Oct.; 2 Ictalurus punctatus, Sept.; 1 Polyodon spathula, May.

Hirudinei: 1 Catostomus teres, Oct.; 3 Ictalurus punctatus, Apr., June; 1 Amiurus nebulosus, May; 5 A. marmoratus, Oct., Nov.; 1 Polyodon spathula, May.

Chætopoda: 1 Aphredoderus sayanus, Sept.

Naididæ: 1 Pimephales promelas, Aug.; 1 Moxostoma macrolepidotum, 2 in., July.

Lumbriculus: 1 Notropis megalops, June.

Lumbricus: 1 Lepomis pallidus, Nov.; 1 yg.

Nematoda: 1 Amiurus nebulosus, Aug.

Gordius: 2 Semotilus atromaculatus, Sept.; 1 Ictalurus punctatus, Oct.

Anguillulidæ: 1 Ictiobus bubalus, Apr.; 1 I. cyprinella, June.

Rotifera: 1 Notropis heterodon, July; 1 Moxostoma, yg.; 3 M. macrolepidotum, $2\frac{1}{8}$–$2\frac{3}{4}$ in., Aug.; 1 Erimyzon sucetta, $1\frac{3}{4}$ in.; 1 yg.; 2 Catostomus teres, June, Aug.; 1 Carpiodes, yg.; 1 Ictiobus, yg.; 1 I. bubalus, yg.

Anuræa: 2 Erimyzon sucetta, yg.; 2 Ictiobus, yg.; 2 I. bubalus, yg.

Brachionus: 1 Ictiobus, yg.

Metopidea: 1 Moxostoma, yg.; 3 M. macrolepidotum, $2\frac{1}{8}$–$2\frac{3}{4}$ in., Aug.; 1 Erimyzon sucetta, $1\frac{3}{4}$ in.; 1 yg.; 2 Catostomus teres, June, Aug.

Rotifer vulgaris: 1 Catostomus teres, June.

Planaria: 1 Noturus gyrinus, Oct.

PORIFERA.

Spongilla: 2 Ictalurus punctatus, Sept.

PROTOZOA.

Dinobryon: 1 Ictiobus, yg.
Euglena viridis: 4 Notropis, yg.
E. acus: 3 Notropis, yg.
Actinosphærium: 2 Ictiobus, yg.
Centropyxis: 1 Carpiodes, Apr.
C. ecornis: 1 Notropis heterodon, July.
Arcella: 1 Erimyzon sucetta, $1\frac{3}{4}$ in.; 2 yg.; 1 Carpiodes, yg.; 1 Ictiobus, yg.
A. discoides: 1 Ictiobus, yg.
A. vulgaris: 1 Ictiobus, yg.
Difflugia: 1 Dorosoma cepedianum, July; 1 Notropis, yg.; 3 N. heterodon, May, July; 1 Pimephales notatus, Aug.; 1 Campostoma anomalum, Aug.; 3 Moxostoma, yg.; 5 M. macrolepidotum, $1\frac{1}{4}$–$2\frac{3}{4}$ in., July, Aug.; 1 Erimyzon sucetta, $1\frac{3}{4}$ in.; 2 yg.; 4 Hypentelium nigricans, yg.; 2 Catostomus teres, June, Aug.; 4 Carpiodes, Apr., Oct.; 1 yg.; 2 Ictiobus urus, Aug., Oct.; 2 I. cyprinella, July; 1 Noturus gyrinus, Oct.
D. globulosa: 1 Gambusia patruelis, Sept.

VEGETABLE FOOD.

Seeds: 3 Fundulus diaphanus, Oct.; 1 Semotilus atromaculatus, July; 1 Notropis atherinoides, July; 2 N. megalops, Apr., Aug.; 6 N. whipplei, Apr., June, Aug.; 3 N. heterodon, May; 1 Moxostoma, yg.; 1 Ictiobus bubalus, Apr.
Corn meal (distillery slops): 1 Dorosoma cepedianum, July; 1 N. whipplei, Aug.; 1 Moxostoma macrolepidotum, Sept.; 3 Ictiobus urus, Oct.; 4 I. cyprinella, Oct.; 2 Ictalurus punctatus, Aug., Oct.; 1 Amiurus nebulosus, Sept.; 1 A. marmoratus, Oct.
Exogenæ: 6 Notropis megalops, June; 1 N. hudsonius, June; 1 Ictalurus punctatus, Apr.
Endogenæ: 1 Micropterus dolomiei, yg.; 3 Notropis megalops, June, July.

Fungi: 3 Notropis, yg.; 1 N. megalops, Aug.; 1 Hybognathus nuchalis, Aug.; 1 Chrosomus erythrogaster, Sept.; 2 Ictiobus, yg.

Terrestrial vegetation: 1 Centrarchinæ, yg.; 1 Pomoxys, Apr.; 1 Esox vermiculatus, June; 1 Hybopsis biguttatus, Sept.; 3 Notropis atherinoides, Apr., May; 4 N. megalops, Apr. Aug.; 3 N. whipplei, Apr., Aug.; 1 N. heterodon, Sept.; 1 Pimephales notatus, Aug.; 1 Ictiobus bubalus, Sept.; 1 I. urus, July; 1 I. cyprinella, June; 4 Ictalurus punctatus, Mar., Apr., Aug.; 1 Amiurus nebulosus, May; 1 Polyodon spathula, May.

Gramineæ, seeds: 2 Notemigonus chrysoleucus, May, Aug.; 7 Hybopsis biguttatus, June, Aug., Sept.; 1 Notropis whipplei, Apr.; 3 N. stramineus, Apr., July; 2 I. bubalus, Apr., Oct.; 1 I. urus, July.

Setaria, seeds: 1 Catostomus teres, Oct.

Aquatic vegetation: 2 Notemigonus chrysoleucus, Aug.; 4 Notropis megalops, Apr., July, Aug.; 3 N. hudsonius, June; 1 Chrosomus erythrogaster, June; 1 Campostoma anomalum, Sept.; 1 Placopharynx carinatus, Oct.; 1 Moxostoma aureolum, Apr.; 2 M. macrolepidotum, May, Sept.; 1 Hypentelium nigricans, Aug.; 5 Carpiodes, July, Oct.; 8 Ictiobus bubalus, Apr., Aug., Oct.; 3 I. urus, July, Oct.; 4 I. cyprinella, Oct.; 4 Ictalurus punctatus, Aug.; 1 Amiurus natalis, 3½ in., Oct.; 1 Amia calva, Aug.; 2 Polyodon spathula, May, June.

AQUATIC PHÆNOGAMIA.

Myriophyllum: 1 Lepomis gibbosus, May.

Ceratophyllum: 1 Lepomis pallidus, May; 2 Pomoxys, Apr., May.; 1 Ictiobus bubalus, Oct.; 1 Amiurus nebulosus, May.

Lemna: 1 Umbra limi, Sept.; 1 Dorosoma cepedianum, July; 1 Placopharynx carinatus, Oct.; 2 Ictiobus bubalus, Oct.; 1 I. urus, Aug.; 1 I. cyprinella, Oct.; 4 Ictalurus punctatus, Sept., Oct.; 1 Amiurus natalis, Oct.

L. trisulca: 1 Pomoxys, May.

L. minor: 1 Ictiobus bubalus, Oct.

Wolffia: 1 Lepomis pallidus, yg.; 1 Aphredoderus sayanus, Sept.; 7 Umbra limi, Sept.; 4 Gambusia patruelis, Sept.; 1 Zygonectes notatus, Sept.; 1 Dorosoma cepedianum, July; 1, $2\frac{1}{2}$ in., July; 1 Placopharynx carinatus, Oct.; 1 Moxostoma macrolepidotum, Sept.; 1 Erimyzon sucetta, $1\frac{3}{4}$ in.; 2 Carpiodes, Oct.; 11 Ictiobus bubalus, Oct.; 2 I. urus, Oct.; 1 Amiurus natalis, Oct.; 2, 2–$2\frac{1}{8}$ in., July.

Naias flexilis: 3 Lepomis pallidus, May, July, Nov.

Potamogeton: 1 Ambloplites rupestris, yg.; 1 Notropis megalops, Apr.; 1 Ictiobus bubalus, Oct.; 3 Ictalurus punctatus, June, Sept.; 1 Amiurus nebulosus, May; 1 A. marmoratus, Oct.; 9 Polyodon spathula, May.

P. gramineus: 2 Ictalurus punctatus, Oct.

AQUATIC CRYPTOGAMIA.

Chara: 1 Lepomis gibbosus, July; 1 Moxostoma macrolepidotum, June; 1 Amiurus nebulosus, July.

Algæ, filamentous: 3 Percina caprodes, Aug.; 2 Lepomis gibbosus, June, Aug.; 1 yg.; 9 L. pallidus, July, Aug., Oct., Nov.; 1 Pomoxys, July; 1 Aphredoderus sayanus, Sept.; 4 Eucalia inconstans, Oct.; 1 Gambusia patruelis, Sept.; 9 Zygonectes notatus, Sept., Oct.; 1 Fundulus diaphanus, Oct.; 2 Dorosoma cepedianum, June, July; 3 Notemigonus chrysoleucus, Aug., Sept.; 4 Semotilus atromaculatus, July; 3 Hybopsis biguttatus, Aug.; 4 Notropis, yg.; 1 N. atherinoides, Aug.; 8 N. megalops, Apr., May, June; 7 N. whipplei, Apr., May, June, Aug.; 7 N. hudsonius, May, June, July; 2 N. heterodon, Apr., May; 3 Pimephales notatus, July, Oct.; 1 Hybognathus nuchalis, May; 2 Chrosomus erythrogaster, Sept.; 7 Campostoma anomalum, Aug., Sept.; 2 Moxostoma, yg.; 1 M. macrolepidotum, Sept.; 1 Erimyzon sucetta, July; 2 Catostomus teres, June, Aug.; 3 Ictiobus bubalus, Aug. Oct.; 3 I. urus, Aug.; 4 I. cyprinella, June, Aug.; 3 Ictalurus punctatus, Oct.; 1 Amiurus nebulosus, May; 1, 2 in., Aug.; 1 Noturus, yg.; 2 N. gyrinus, May; 3 Polyodon spathula, May, June, Aug.

Algæ, unicellular: 1 Dorosoma cepedianum, July; 2 Notropis, yg.; 2 N. whipplei; 1 N. hudsonius, July; 1 Pimephales

promelas, Aug.; 1 Moxostoma, yg.; 1 Ictiobus, yg.; 1 I. bubalus, yg.; 1 I. urus, Aug.; 1 I. cyprinella, Aug.

Cladophora: 4 Ictalurus punctatus, Oct.

C. glomerata: 1 Notropis megalops, June.

Vaucheria: 1 Ictiobus urus, Aug.; 1 Ictalurus punctatus, Aug.

Scenedesmus: 2 Ictiobus cyprinella, Aug.

Protococcus: 1 Dorosoma cepedianum, $2\frac{1}{2}$ in., July; 1 Erimyzon sucetta, $1\frac{3}{4}$ in.; 1 Ictiobus bubalus, yg.; 1 I. cyprinella, Aug.

Glœocystis: 1 Notropis whipplei, Apr.

Spirogyra: 1 Semotilus atromaculatus, July; 2 Notropis, yg.; 1 N. whipplei, Apr.

Diatomaceæ: 1 Gambusia patruelis, Sept.; 3 Dorosoma cepedianum, Apr., July; 1, $2\frac{1}{2}$ in., July; 2 Notemigonus chrysoleucus, Aug.; 3 Notropis, yg.; 2 N. megalops, May; 2 N. whipplei, May; 2 N. hudsonius, June, July; 5 N. heterodon, May, July, Sept.; 1 Pimephales notatus, July; 2 Hybognathus nuchalis, May, Sept.; 1 Chrosomus erythrogaster, Sept.; 1 Campostoma anomalum, Sept.; 1 Moxostoma, yg.; 1 Erimyzon sucetta, July; 1 yg.; 5 Hypentelium nigricans, yg.; 1 Catostomus teres, June; 3 Carpiodes, Mar., Sept., Oct.; 2 yg.; 1 Ictiobus bubalus, Aug; 4 I. urus, June, Aug.; 3 I. cyprinella, Apr., Aug.; 1 Amiurus nebulosus, 2 in., Aug; 1 Polyodon spathula, June.

Pinnularia: 1 Gambusia patruelis, Sept.

Pleurosigma: 1 Moxostoma macrolepidotum, $2\frac{3}{8}$ in., Aug.

Cymatopleura: 3 Notropis, yg.

Desmideæ: 1 Notropis megalops, May; 1 Pimephales notatus, Aug.; 2 Moxostoma, yg.; 1 M. macrolepidotum, $2\frac{3}{4}$ in., Aug.

Closterium: 3 Notemigonus chrysoleucus, Sept.; 4 Notropis, yg.; 2 Moxostoma, yg.; 5 M. macrolepidotum, 2–$2\frac{1}{2}$ in., July, Aug.; 1 Erimyzon sucetta, $1\frac{3}{4}$ in.; 2 yg.; 2 Hypentelium nigricans, yg.; 2 Catostomus teres, June, Aug.; 1 Ictiobus, yg.; 1 Carpiodes, yg.; 1 Ictiobus bubalus, yg.; 1 I. cyprinella, Aug.

Cosmarium: 4 Notropis, yg.; 1 M. macrolepidotum, $2\frac{3}{4}$ in., Aug.; 1 Erimyzon sucetta, $1\frac{3}{4}$ in.; 2 yg.

Staurastrum: 1 Erimyzon sucetta, yg.; 1 Ictiobus cyprinella, Aug.

Nostoc: 2 Ictiobus cyprinella, Aug.; 1 Polyodon spathula, Aug.
Oscillaria: 1 Chrosomus erythrogaster, Sept.; 1 Ictiobus, yg.
Chroöcoccus: 1 Erimyzon sucetta, $1\frac{3}{4}$ in.; 1 yg.

Dirt: 10 Dorosoma cepedianum, Apr., June, July, Oct.; 4, $2\frac{1}{2}$–$5\frac{1}{4}$ in., July, Oct.; 1 Clupea chrysochloris, $1\frac{3}{8}$ in., June; 10 Notemigonus chrysoleucus, July, Aug., Sept.; 3 Hybopsis biguttatus, Aug., Sept.; 2 Phenacobius mirabilis, Sept., Oct.; 1 Notropis hudsonius, May; 1 N. heterodon, Sept.; 8 Pimephales notatus, July, Aug., Sept., Oct.; 4 P. promelas, May, Aug.; 8 Hybognathus nuchalis, May, Aug., Sept., Oct.; 3 Chrosomus erythrogaster, June, Sept.; 9 Campostoma anomalum, Aug., Sept.; 3 Moxostoma, June; 2 M. aureolum, June; 3 M. macrolepidotum, June, Sept.; 2, $2\frac{1}{8}$–$2\frac{3}{4}$ in., Aug.; 1 Minytrema melanops, Sept.; 1 Erimyzon sucetta, July; 6 Carpiodes, Mar., Apr., July, Oct.; 5 Ictiobus urus, Aug.; 1 I. cyprinella, Aug.; 1 Amiurus nebulosus, Sept.

INDEX.

Where reference is made to an item relating to *the food* of a species or other group, an asterisk (*) has been placed after the page number; to indicate that the object *has been eaten*, a dagger (†) has been used.

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